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Main hall in the New York Aquarium, showing large tanks where big fish live in comfort.

Curious specimens seen in the smaller tanks. On the left are the spade fish; on the right the trunk fish.

IN THE NEW YORK AQUARIUM.—[See page 52.]

Radioactivity*

Advances in a Theory That Has Enabled Us to Study Natural Transmutation

THE theory of radioactivity has not too many adherents outside the small circle of workers in this domain. It has taken man long years to grasp the meaning of the indestructibility of matter. But it was worth mastering that conception. The young chemist had long since understood that he must reproduce all the metal that he has passed through reactions, or must account for the loss. An element is an element; properties change, the mass must remain. During the last decade he has been told that elements are, after all, mortal things, that they beget elements, that they may live for thousands of years or a fraction of a second, that they pass through an amazing tangle of disintegrating changes, and that the mass of the atom undergoes changes like all properties. It sounds all fantastic and bewildering. And yet the exposition of the phenomena by some of the investigators seems to admit of arriving at as definite conceptions as the old views did. Professor Soddy is one of those searchers.

Reviewing "Advances in the Study of Radioactive Bodies" in two remarkable Royal Institution lectures, Prof. Frederick Soddy, M. A., F.R.S., now Professor of Chemistry at the University of Aberdeen, stated that the theory, put forth in 1902, that radioactivity was a consequence of the disintegration of certain elements through a series of short-lived elements by expulsion of helium atoms, had at first sight appeared revolutionary to the chemists, as incompatible with the atomic theory. He ventured to think, however, that this opinion would be modified, the more so as the chemical atom was being put on its proper basis by the elimination of views which had been introduced into the atomic theory without being proper to it. The new ideas were not so novel as they might appear. Sir James Dewar had drawn the lecturer's attention to some characteristic opinions of the past century. Thus Herschel had written: "Philosophical chemistry no more aims at determining the one essential element out of which all matter is formed —the one ultimate principle of the Universe—than astronomy at discovering the origin of the planetary movements, or geology at ascending to the creation of the earth. There may be such an element. . . . Should we ever arrive at an analysis of the bodies now considered elements . . . it would undo nothing that has been done, and render useless no point of knowledge which we have yet arrived at." Again, Samuel Brown, of Edinburgh (not the Brown of the Brownian movements, a contemporary Edinburgh man), speaking of Lavoisier, had written in 1820:— "His definition of elements was perfect: a material substance, not yet analyzable . . . It is hard to think that all those sixty creatures are truly simple or elementary. The greatest question in science is: What is the interior nature of the elements?"

By the aid of radioactive studies, Professor Soddy continued, changes altogether different from anything previously known had been discovered, and, in his opinion, the disintegration theory confirmed details of the atomic theory. When he spoke in the same place in 1912, he had referred to two outstanding problems. The first was the origin of radium, a problem which he had been investigating for twelve years; it was unexpectedly complicated, but might now be considered as solved. All researches pointed to uranium as parent; but there was an intermediate product, ionium, the life-period of which was about 80,000 years, being thirty times longer than the life-period of radium. Experimenting during the last few years with 3 kg. of uranium, in addition to three other samples, each of about one half kg., he had been able to determine that the rate of production of radium from uranium was really proportional to the square of the time. The transport of the glass flask containing the 3 kg. of uranium from Glasgow to Aberdeen had been a task of grave anxiety to him.

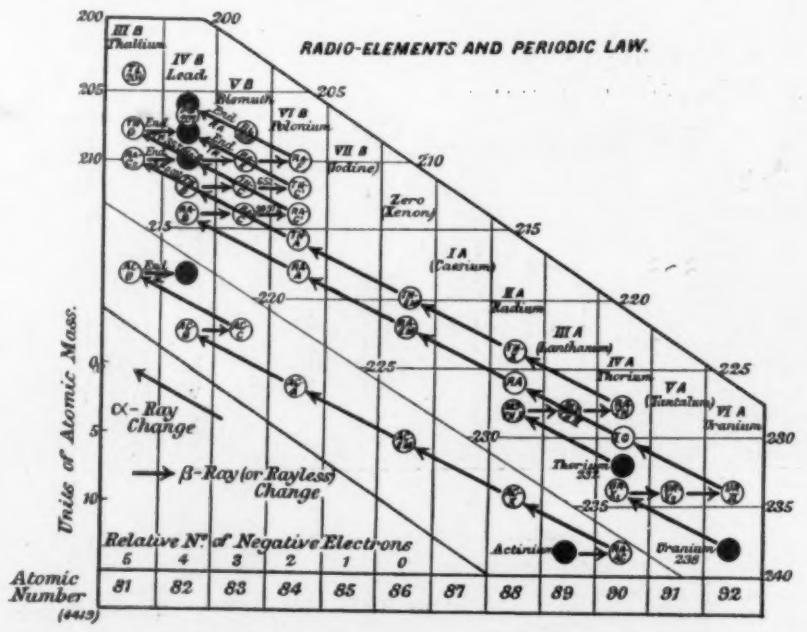
In the second problem—determination of the final products of the disintegration series—considerable progress had likewise been made. The problem was practically solved already, indeed, incidentally almost in consequence of one of those broad sweeping advances of knowledge which science made but rarely, but which, when they occurred, seemed to carry everything before them, leaving in their wake confirmatory researches in plenty, but for the moment no fresh world to conquer.

The three disintegration series—uranium-radium, thorium, actinium—all seemed to end in the ultimate product lead, or some substance chemically indistinguishable from lead. But the changes were extraordinarily complex, owing to the large number of intermediate products; some of these had life-periods of many years, others of a fraction of a second, and in the latter case any inquiry into chemical properties was impossible, of course. The ores containing the radioactive materials were extremely complex to start with. Yet the task had not been so bewildering as it had at first appeared, because many of the intermediate products had been found to be identical with one another in chemical nature. The recent age had brought out and destroyed several apparent identities. The resemblance between argon (and the other inert gases) and nitrogen had been strong enough to prevent discovery of these gases for a long time; but the resemblance had, after all, been superficial. The resemblances between the different rare-earth elements were, on the other hand, so unique that Crookes had, years ago, made the suggestion of meta-elements—i. e., elements gradually and imperceptibly changing from one well-defined form to another. But nobody had till recently contemplated the possibility of different elements possessing, not similar, but identical, chemical character, or pondered over the philosophical consequences of that assumption. If argon had chemically been identical with nitrogen, its higher atomic weight and density would still have led to its separation, by diffusion experiments, for instance. If, then, elements with chemically-identical properties existed, chemical analysis would be powerless to reveal them; but it did not follow that any other kind of analysis would be equally powerless.

From this standpoint Professor Soddy argued that the chemist's analysis was at bottom, after all, still an analysis into properties, rather than into constituents, and that the periodic law was an expression of the step-by-step change of the chemical properties of elements rather than a step-by-step change in the constituents of matter. Earth, air, fire, water had been the elements of the early mind, the four possible combinations of two fundamental qualities and their opposites, hotness and coldness, wetness and dryness, taken two at the time. "In spite of Boyle and Dalton and Mendeleieff," asked Professor Soddy, "can the chemist claim even yet to have grasped the reality beneath the appearances, the constituents beneath the qualities? Indeed, he cannot. The ancient Hellenic heresies pursue him still, only in subtler guise; for the search after reality, which is the object of physical science, is never ending. It is a well-marked road; some of us think it the only road worth pursuing, only the more so because there is no goal." What appeared constituent to us might be considered property by the next generation.

Passing on, he explained that radioactivity had placed new analytical means at the disposal of chemists. Chemical properties might be called the life properties of a substance, radioactive phenomena its death properties. The former were now ascribed to the outer shell of electrons, the latter to the inner nucleus. The general law was that a loss of an α ray (a helium atom of atomic mass 4) carrying two positive charges shifted the position of an element in the periodic table by two places in the direction of diminishing mass, while a β-ray change, a loss of one negative β particle, shifted the position of the element by one place in the opposite direction; the latter change relatively increased the positive charge by one unit. Thus one α-ray change followed by two β-ray changes would bring the element back into the same place of the periodic table (see diagram sub-joined), and the many changes would bring different elements into places already occupied. The great generalization (of Soddy and Fajans) was now that the same place in the periodic table might be, and was frequently, occupied by several elements, chemically identical. Such elements were called "isotopes." That view seemed destructive of the fundamental importance of the atomic mass. But the researches of Moseley on the characteristic X-rays and other researches proved that the periodic law really expressed the relation between chemical properties and the net charge upon the atom, not the relation between properties and the atomic mass. That net charge upon the atom was the "atomic number."

We reproduce Prof. Soddy's table of the radioactive elements. He plotted the three disintegration series on ordinates of atomic mass, the abscissæ being the atomic numbers. The group of the periodic table is indicated at the top of a column, and the head element underneath it [in brackets if not horizontally in the correct position as to atomic weight]. The uranium-radium and the thorium series are shown together; the actinium series is kept separate owing to the uncertainty with regard to the atomic weight of actinium. The difference between consecutive atomic numbers was always one unit, while the difference between the atomic weights of the consecutive members of Mendeleieff's table ranged from a fraction of a unit to several units. On the atomic number theory 94 elements—not counting isotopes, occupying the same space—were possible, of which five remained to be discovered. The emanations fell into place 86; 87 and 85 were always vacant, because in this part of the disintegration series there was a succession of α-ray ranges without β-ray changes, and the alternate places of the periodic table were missed. The final disintegration products (three main, two branch products) should be found in place 82 of lead, and uranium lead should have the atomic mass: uranium (226) — 5 helium (20) = 206; the actual determinations made by Th. W. Richards and Lembert, Maurice Curie and Hönigschmidt and Horowitz with materials from various ores, ranged from 206.86 to 206.04; the most recent determinations by the last two workers with specially selected ores (pitchblende, uraninite, brögerite) had yielded the lowest values—little higher than 206. Thus uranium-lead certainly had a lower atomic weight than ordinary lead (from common ores not uranium ores), to which the international table assigned the atomic weight 207.1. On the other hand, thorium-lead should have the atomic weight thorium (232.4) — 6 helium (24) = 208.4. The determination was exceedingly difficult, because thorium ores were most complex and contained uranium, which changed three times more rapidly than thorium. The lecturer's own experiments with 30 kg. of Ceylon thorite (containing only 1 or 2 per cent of uranium) had yielded the value 207.64; only one determination had been made so far with this material, but it confirmed a preliminary research which Professor Soddy had conducted in conjunction with Mr. H. Hyman when they had only one gramme of lead from Ceylon thorite at their disposal. He had also examined this lead spectroscopically and had found no difference from the ordinary lead



* Reproduced from *Engineering*.

spectrum, except that one weak line was too bright. Isotopes should give the same spectra, because the spectrum was an electric phenomenon, not dependent on mass; he considered that the work of Rutherford and Andrade settled this question in the same sense. though he admitted that they differed from Hicks and others on this point, and that little work had been done in this field. Volatility and melting-point experiments should not bring out differences between isotopes either, Prof. Soddy thought; but diffusion experiments did, and J. J. Thomson's positive-ray analysis should do so. The periodic table might suitably be represented after Crookes, who had suggested grouping the elements on a continuous curve of convolutions of 8 shape; Professor Soddy would make the spiral helical, and would begin with two single loops (corresponding to the short groups of Mendeleieff) followed by 8-shaped loops.

Concluding, Prof. Soddy remarked that the problem of the ultimate constitution of the atom was undergoing rapid advance. The constitution of the atom remained the great question. In organic chemistry synthetizing was only possible after the structure of the compound had been determined. Nobody could predict whether the transmutation of the elements would ever be accomplished. But the problem now looked tremendously different from that of the alchemists. In their sense (gold-making) the solution was not desirable, and since gold did not appear to have isotopes it did not look at all likely. Radioactivity, however, enabled us to study natural transmutation. The radioactive elements were endothermic elements, breaking down with enormous liberation of energy. Within the structure of the atom was bound up energy a million times greater than any yet utilized. That energy was not yet available; but the solution of the transmutation problem would render it available.

We have been unable to enter into the details of several of the varied recent researches discussed, which were conducted by Prof. Soddy and Mr. Fleck and by others, to whom he, of course, gave full credit. We may mention some results of Prof. Soddy's work: polonium, which, at first alone of all the radioactive elements, seemed to have no isotopes, had six isotopes, all of short life; and the problem of the origin of actinium involving the nature of ekatantalum, remained uncertain.

Liquid Trade Wastes

A Difficult Problem in River Polution

THE subject of liquid wastes from manufacturing processes has been a thorny question ever since manufactures arose in England. A visitor to Yorkshire finds it difficult to conceive that the inhabitants of the county ever "drank of the Calder and washed in the Aire," as is asserted by the ancient couplet, and he realizes that the immense activity of the district is now quite incompatible with such a delightful state of affairs. For years there have been disputes between the manufacturers, the municipalities, and the river authorities as to what should be done to convert the present black and foul streams into something less obnoxious to sight and smell. The rivers pollution prevention act of 1876 certainly provided drastic remedies, but it contained a saving clause to the effect that they were not to be applied if they were likely to inflict material damage on the industry of a district. In the then state of knowledge, they would have depopulated a considerable part of Lancashire and Yorkshire, shutting up hundreds of manufactories. The rivers would certainly have been the better, but the improvement would scarcely have reconciled the inhabitants to the immense losses and widespread poverty which would have ensued. Naturally, the saving clause became the dominant feature of the act, and the rest remained, to a great extent, a dead letter.

In a recent issue we called attention to the ninth and last report of the Royal Commission on Sewage Disposal. This commission has been sitting seventeen years, and during that period has both amassed and disseminated a vast amount of useful information, so that, at length, we begin to see light through the very obscure subject of sewage purification.

The recommendations of the ninth report deal mainly with trade-wastes, and are framed in a strictly compromising spirit. They aim at doing what is practically possible, both scientifically and financially. The authors realize that the ideal river is not to be had in a busy manufacturing district; but, at the same time, they realize that an immense improvement upon the existing state of affairs can be attained if manufacturers will take such steps as are perfectly feasible, and will see that they are carried out with the same care which they devote to other departments of their businesses. Unfortunately, the purification of wastes offers little hope of a profit. In certain instances there may be obtained by-products which tend to lessen the expense; but oftener the outgoings bring no return, and hence the process is apt to be carried out in a perfunctory spirit. If these recommendations are adopted, and it looks as if the local government board could adopt them under the act of 1876 without further legislation, then we may expect at least a great improvement on the present state of affairs. Possibly further scientific discoveries in the future will enable greater demands to be made and readily complied with, and we may then attain to a condition in our rivers which, for the present, is only a pious aspiration.

The ninth report of the commission contains particulars of a great number of purification plants laid down by manufacturers, with analyses of the entrant and effluent liquids. These refer to many kinds of works and processes, such as coal-washing, tin, lead, and zinc mines, china-clay pits, stone-quarrying and polishing, cotton-dyeing, printing and bleaching, wool-dyeing and scouring, the manufacture of paper and cardboard, breweries, maltings, sulphate cellulose works, fellmongers, tanneries, dairies, shale-oil distillation and spent gas liquor. The apparatus are, however, curiously alike, although the trades are so different. They consist of precipitation tanks, with or without filters, and by these simple means it is clearly possible to improve very many trade-wastes to such an extent that they may be turned into streams without giving rise to serious nuisances. It is pretty clear, however, that in many instances the existing plants have been designed in too niggardly a spirit. They are on the right lines, but they are not of sufficient capacity to allow the processes of agglomeration and deposition, followed sometimes by bacterial purification, to develop to the required extent. They effect a great improvement, but they do not always carry it to that point at which the river may be expected to complete the process without giving evidence of pollution. Many trade-wastes are, of course, not amenable to bacterial purification, and a filter can only act mechanically upon them. Whenever possible the commission favors their discharge, either directly or after precipitation, into the sewers, in order that they may be greatly diluted, after which it is easier to deal with them by ordinary processes. Of course, this supposes that the trade-wastes are much less in quantity than the ordinary sewage, and this is not always the case. For instance, at Burton-on-Trent, twenty years ago the brewery waste was three times the volume of the domestic sewage, and, for a time, rendered the sewage farm unworkable. Generally speaking, however, a moderate amount of trade-waste does not seriously interfere with sewage purification, while the admixture of sewage from a septic tank appears to render more easy the purification of many manufacturing wastes.

The general recommendations of the commission are that the effluent from a works shall not contain more than four to six parts—the number depending on the type of waste—of suspended matter in 100,000 parts, and shall not absorb more than two to six parts of dissolved oxygen in five days. It is not pretended that such discharges will produce pellucid streams, but that they will be a great improvement on many that now exist. At first sight it seems strange that a few grains more or less of suspended matter in nearly a gallon and a half of water can have any perceptible effect, but it must be remembered that the flow goes on day by day, and that the suspended matter is apt to accumulate in the bed and on the banks of the stream, and to produce a mud which is always unsightly, and which may be noisome, for the suspended matter is often of organic origin, and may give rise to putridity. Even if the suspended matter is inorganic, such as coal or stone-dust, it may still form mud, and may be destructive of fish-life by sealing up the spawn beds. The dissolved impurities are, however, in many cases of greater importance as sources of pollution. There are several industries that turn out effluents that are four or more times as polluting as ordinary sewage, and the oxygen test is designed to prevent the entrance of such effluents into streams until they have been enormously reduced in strength by the nitrification of the organic constituents. The process of purification is continued in the river as long as it contains free dissolved oxygen, but when the oxygen is exhausted putrefaction sets in. There are many rivers in the manufacturing districts which have little or no free oxygen in dry weather in consequence of their receiving so much organic matter; hence the stringency of the tests in this respect.

The commissioners class 19 types of trade-wastes as those in which efficient purification is practicable, 7 as only partly practicable, and 2 as incapable of being so treated that the effluents can be discharged direct into streams. Those in which engineers are more or less directly interested mostly fall in the first category, and are coal-washing, mining, quarrying, tin-plating, galvanizing, and wire-drawing. The wastes from the first three can be dealt with by precipitation solely, and require no bacterial treatment, as they do not contain organic matter. Tin-plating, galvanizing, and wire-drawing furnish wastes which are strongly acid with mineral acid, and contain much iron in solution. The stronger liquids should not, in any circumstances, be discharged into streams, and there is no practicable means of rendering them innocuous. The only means of dealing with the waste-pickling liquor is to concentrate it by evaporation in lead pans until it deposits green copperas in crystals. The mother-liquor can then be mixed with fresh sulphuric acid and used again. The hydrochloric-acid pickle can also be concentrated by evaporation and used as a disinfectant, or it may be decomposed by lime, or by a mixture of lime and chalk, which transforms the muriate of iron into a muriate of lime, which is innocuous. The oxide of iron is precipitated in the process and is a saleable product. The wash-waters in which sheets and wire are rinsed after the pickling can be neutralized by lime and settled, after which they are fit for discharge into rivers.

The industries which yield wastes for which efficient purification is not, in the present state of knowledge, practicable are bleaching, cotton-dyeing and printing, woolen-dyeing and printing, and some paper works. Nevertheless, a great improvement can be effected in the effluent liquors by deposition and filtration. Unfortunately, it is just to the wastes from these trades that a great deal of the pollution of the northern rivers is due, and research is urgently needed to find new methods of dealing with them. The wastes from bleach works contain lime, chlorine, acid, starch and organic matter in really enormous quantities. The report mentions one works in which 30 to 40 tons of dried sludge are removed every three weeks from the settling-tanks. The fact, however, that this quantity of matter is kept out of the rivers shows how necessary it is that a reasonable standard of purity should be enforced on all manufacturers. The waste from dye works is of a much more innocent nature, being equal to a very dilute sewage, but it has the disadvantage of blackening the river into which it is turned, and rendering it unsightly, if it does not actually pollute. While it is possible to remove the color by bleaching agents, the cost of the process would, in many cases, be in excess of the benefit to the river. A good deal of the color can, however, be removed by chemical precipitation, and still more by filtration through land or through pressure conguiant filters. Wool-scouring, of course, produces an exceedingly polluting liquid, which needs to be extensively diluted with the wastes from woolen dyeing and other processes which yield a weaker liquor. It can then be dealt with by precipitation to produce a non-putrescible effluent.

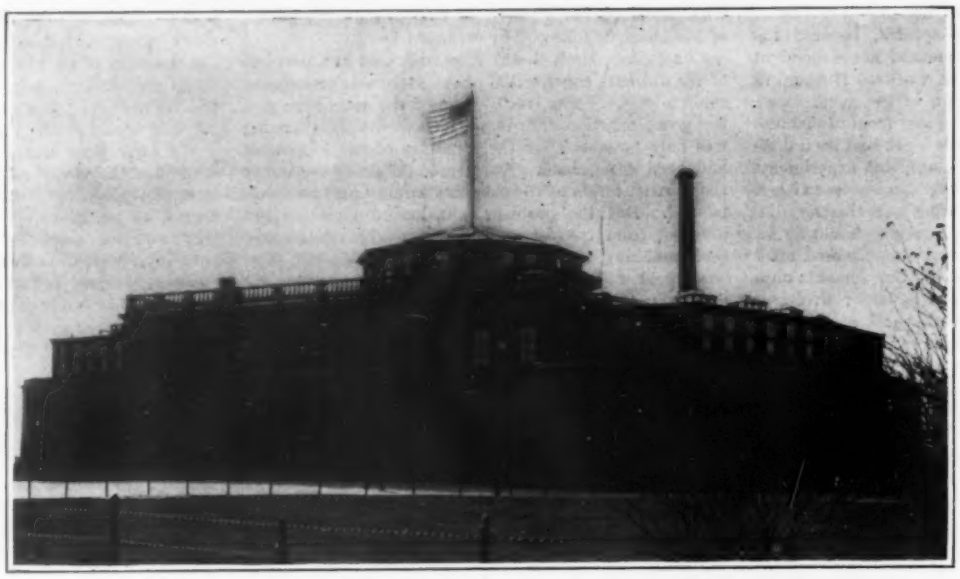
The two remaining industries are sulphite cellulose manufacture and gas and coke production, and for these the commissioners are not aware of any method of treatment so that the effluent can properly be discharged direct into streams. The waste liquor from sulphite cellulose manufacture contains 10 per cent of solid matter, of which four-fifths is organic. There are, however, only two works in this country, and one of these is situated on a relatively large river, and at the other the stronger liquid is not discharged into the stream, but is evaporated, so that the matter has no great importance. Spent gas liquor is produced when gases are treated for the recovery of ammonia. It contains a large amount of nitrogen in various forms, and takes up oxygen with such great avidity that its entrance into a river is most deleterious. It also contains phenols, which are destructive of bacterial life; but the commissioners say that up to 2 per cent may be added evenly to sewage without damaging the filters. Failing this it may be evaporated or purified by Dr. Fowler's process, but further research is urgently needed to discover some cheap and easy way of dealing with this liquor.

This exhausts the list of trades dealt with in the report, and it is pleasant to find that at last a *via media* has been found between the demands of the more rigorous river authorities and the contentions of manufacturers.—*Engineering.*

Collections of the New York Aquarium*

A Famous Institution Known to Naturalists and Sportsmen Throughout the World

By R. W. Shufeldt, M.D.



The unpretentious building that houses a varied and notable collection.

VERILY the lovers of the outdoor world may often have their interest and enthusiasm aroused through an exploring trip that takes them into the highways and byways of some great zoölogical park or indoor world, where many of the denizens of the forest, plains and streams may be seen and studied at a time when rifle, rod and reel have no place in the mind of the sportsman observer. A magnificent domain of this character is to be found in the National Zoölogical Park and Garden at Washington, with its hundreds of acres of forests, open country, and wild glens, through which run streams and rivulets, amidst scenery which is almost entirely or quite primeval in character. Within this area are to be found breeding everywhere, in their natural haunts, the majority of the small land birds of the Middle Atlantic States, in addition to herons, vultures, woodcock, quail, and other species. Moreover, in the same area occur, in the wild state, raccoons, rabbits, muskrats, and many other small mammals—and all this within the city limits!

Such a Garden scarcely belongs in the category of the "indoors," which is a term more pertinently applied, in so far as the lover of the outdoors is concerned, to zoölogical gardens of more modest pretensions, or to those museums in which are to be found elegant mounted groups of moose, elk, deer, and every variety of game bird, the quest of which ever lures him into their haunts in nature,—be it to the tops of the rugged, snow-clad mountains, or over the boundless prairie of the West.

Great aquaria are to be similarly classified, for in them we may see, admire, and study, in their great tanks of limpid water, our favorite fishes, as well as many other aquatic forms so familiar to the angler and to the amateur naturalist the world over.

There is no public aquarium in the United States offering anything like the attractions, a greater number or variety of living specimens, or a more beautiful display of living fishes and other denizens of lake, river, and ocean than does the now famous Aquarium of New York City. Each year many, many thousands of visitors pass through this institution as one of the greatest attractions to be found in that metropolis. As we would naturally expect, the vast majority of these are mere sight-seers; but upon the other hand, a fair proportion consists of the best class of American sportsmen, amateur and professional naturalists, and students of technical ichthyology.

Among these various classes, the New York Aquarium is known all over the world, while at the same time, there are many who have never enjoyed the opportunity to make a personal visit there; it is for such as these that the present article has been prepared.

Several years ago, Dr. Charles H. Townsend, the Director, gave me the use of a commodious study there while I was, for nearly two years, engaged upon anatomical researches on the many species of fish that, for one cause or another, died, either in the tanks or on their way from Bermuda. Doctor Townsend extended every possible facility to me during the time in question, and I naturally came to know a good deal about the institution and its history.

As long ago as 1807, the building of the structure now known as the New York Aquarium was commenced, since which time many of the early records have been lost, though it appears to be quite certain that it was occupied along about the Autumn of 1811. It was deeded to the United States by the city authorities on November 17th, 1807, and erected by the Government as a fort, though it was called Castle Clinton after the war. At that time it had a battery of thirty guns; and during the summer of 1907, when my work was being done there, the old embrasures were shown me in the outer wall which is nine feet in thickness, while those of the old ammunition rooms are about fifteen feet through, or about as useful for the purpose of defense against modern artillery as a sheet of paper.

Congress turned this old fort over to the City of New York in 1823; it then became Castle Garden and was remodeled as a fashionable place of amusement, and it would seat about 6,000 persons. Formerly, it was connected with Battery Park by a bridge, but this intervening space was filled in long ago.

From some of the old records we learn that General Lafayette was received in the building in 1824, and eight years thereafter General Jackson was received there; also President Tyler in 1843, followed by Louis Kossuth in 1851. Much earlier than this—or in 1835—the inventor of the telegraph, Professor Morse, demonstrated before those gathered in the building to hear him, the practicability of controlling the electric current. P. T. Barnum first engaged Jenny Lind to sing there in 1850, and many other distinguished persons were received there in those days, among them the Prince of Wales and President Van Buren. For thirty-five years it was used as a landing-place for immigrants (1855 to 1890), during which time upwards of eight millions of these flowed into the United States through its doors.

On the 10th of December, 1896, the City opened it as an aquarium, and on the 1st of November, six years afterwards, it was transferred from the Department of Parks to the New York Zoölogical Society. Since then many millions of people have visited the superb collection of living fishes and aquatic animals kept on exhibition there. As long ago as 1906, the attendance was, for that year, 2,106,569, or an average of 5,771 a day.

Few of the world's great aquaria exceed in size the one in New York City, and surely no one of them is doing anything like as much along educational lines. In its vast collection there are more living specimens of fish and other forms of aquatic life than possessed by any other institution of the kind in existence. It has no fewer than four immense floor pools; nearly a hundred wall tanks, and upwards of forty small ones. Many species are also kept in reserve tanks not seen by the every-day visitor. The largest floor pool has a diameter of thirty-seven feet and a depth of seven feet; great sea turtles and big fish live in it in comfort.

The brown parrot fish.

Among the large number of species of fish on exhibition, anglers may here study, under the most favorable circumstances, many varieties of trout, pickerel, salmon, bass, perch, and other kinds in which he is especially interested. Here, too, may be seen at all times various species of frogs and salamanders, alligators and crocodiles, marine mammals, and many salt water and pond invertebrates, including crays, prawns, and so on.

Most of the fishes are brought from Bermuda, upon which island there is also a fine aquarium. Both fresh and salt water fishes are on exhibition, and northern as well as tropical species. To maintain these in health and with attractive surroundings in their respective tanks requires a complicated water supply system, which, though very efficient, need not be described here.

Some of the fish and turtles in the building have lived to become five or ten years old, and at one time a dead Nassau Grouper was turned over to me to skeletonize, which weighed upwards of twenty pounds, and which had lived in the Aquarium over seven years.

This New York Aquarium has also its economic side, for through its elegant hatchery it stocks the State waters every year with thousands of fry of food and game fishes; indeed, as many as two millions of these have been distributed to many parts of the country in the course of a twelve-month, and the supply is upon the increase.

As an educational center of its kind, it surely has no rival, for its research laboratory, well stocked with living forms of many kinds, is visited during the course of every year by no fewer than five thousand or more school children with their teachers. Professors also study at this laboratory, as well as other scientific observers in various branches of marine investigation, ichthyology, and the biology of aquatic types.

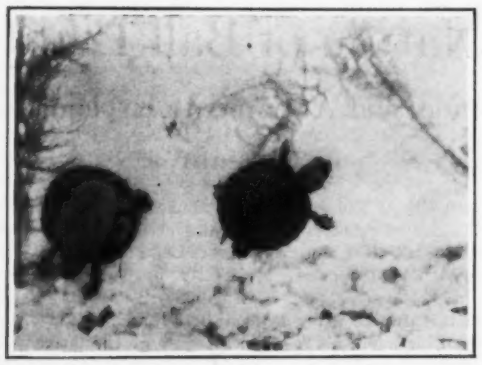
Over 150 schools of Greater New York have their study aquaria looked after by a member of the staff at the Aquarium; and it is not difficult to imagine to what extent this class of nature study is thereby cultivated and advanced. In addition to all this there is maintained at the Aquarium a fully equipped photographic gallery for the purpose of securing negatives, at all times, of every living form brought into the building. Some of the work done in this department is of the highest order, as the cuts illustrating this article demonstrate. There is a library of nearly one thousand volumes in the office of the Director, chiefly treatises and text-books on fish, aquatic animals, aquaria, and many other works more or less akin to these.

The Aquarium also publishes from time to time a beautiful and instructive Bulletin, elegantly illustrated with half-tone cuts of great interest to every one devoted to the study of fishes, angling, marine and fresh water animals, care of aquaria, and similar subjects. It also gets out an Annual Report of distinct value, together with a "Nature Series,"—the latter being a popular publication for the average reader.

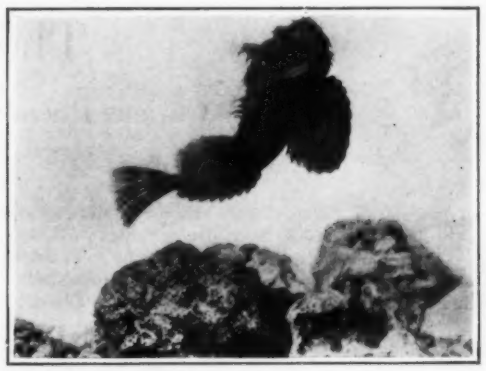
The time is not far distant—at least let us hope so—when the present old-fashioned structure will be replaced by the new and modern one, of fully three times its proportions. It will admit the enormous throng of thousands who daily visit this institution; it will also

* Photographs by members of the Aquarium staff, and here used by special permission of the New York Zoological Society.

The grass porgy.



Young geographical turtle.



Sea raven in swimming attitude.

afford the very necessary space for office and administrative rooms, library, photographic gallery, research rooms, and so on. During recent years, a great quantity of scientific work has unavoidably been forced upon this institution, and this can not be well or properly taken care of until the new structure, for which elegant plans have already been submitted, is completed in all particulars.

Dr. Charles H. Townsend, the present Director, has made a notable fight to carry all this to a successful termination, and he is most eminently deserving of having his aims and aspirations in this direction materialize. There is no limit to his courteous treatment of those who come to the Aquarium, either as visitors or as investigators of material under such facilities as the institution affords, remaining for perhaps several weeks or more at a time. Doctor Townsend will go almost to any length in his efforts to assist such researchers, and his kindness to me during the many months of my labors in one of the rooms there is not likely to ever be forgotten. He even allowed me, in my exceedingly contracted workshop, to macerate fishes, both great and small, in plain water, in that their skeletons might be obtained. In this, Mr. Robert Sutcliffe, his secretary, often assisted, and he could be implicitly relied upon to stand by me in the event of trouble. Sometimes the most diabolical odor would arise during the operation of changing the water on these decaying specimens; but, as fortune would have it, it never seemed to float around as far as the Director's office, in another part of the building and some distance removed.

However, on one broiling hot day in July, in the middle of the forenoon, Mr. Sutcliffe essayed to assist me to change the water on a big Nassau Grouper which, unfortunately, had been macerating rather far over time. There was little or no ventilation, and to our dismay the air of the "laboratory" was simply overpowering. We did out best to dispel it, but with very indifferent success. A riot seemed to be underway in the main exhibition hall below, and the voice of the Director could be distinctly heard in one of the corridors. Our plans were quickly acted upon. With the hose we hastily washed out the waste sink, and with great rapidity we changed the water in all the macerating jars containing specimens; so that, when Doctor Townsend entered, we were engaged in labeling some *dried* skeletons, with all the indifference we could assume.

"For heaven's sake, Doctor," he exclaimed, "where in the world is all this outrageous stench coming from?"

"Stench?" said Mr. Sutcliffe and I in surprise, innocently sniffing the air at the remark; "why, we have not noticed anything you might call a 'stench'!"

Observing that our well-feigned surprise somewhat staggered him, our advantage was backed up by my remarking that perhaps one of the seals had died in the tank during the night, and that the unusually warm weather had had the usual effect.

"And," said he, following up this suggestion, "just driven upwards of five thousand Italian visitors out of the building."

Then, with a somewhat ghastly smile: "I'll go a long ways toward assisting a scientific researcher, but it must not be at the expense of ruining my record year for visitors at the Aquarium. Please change the water a little oftener." And with this gentle and encouraging rebuke, he quietly departed for some other part of the building.

My collection now contains a fine series of skeletons of Bermuda fishes for description.

Catalytic Agents

Their Relation to Modern Methods

The tendency of modern processes to develop on strictly scientific lines is, perhaps, illustrated in no more striking manner than by a consideration of the extent to which the principle of catalysis has been turned to account in more than one branch of present-day gasworks practice. Even in the comparatively early days of the gas industry processes embodying this principle were introduced, although it is questionable whether their catalytic nature was realized at the time. To-day, however, a more extensive knowledge of the behavior of these bodies has paved the way to a solution of far-reaching problems.

The work of M. Vignon has been referred to in these columns on a previous occasion. During the last few months this investigator has again been at work and—among other things—has definitely established the suitability of a number of catalysts for carrying out his theory. In the ordinary way "blue" water-gas, as manufactured in gasworks, contains about 50 per cent of hydrogen and 40 per cent of carbon dioxide, while hydrocarbons, with the exception of a negligible quantity of methane, are entirely absent. On this account the gas is of but little value for distribution purposes, owing to its diluent properties as regards both heating and illuminating power. Vignon, however, endeavored to account for the small proportion of methane present, and eventually concluded that it was the outcome of a catalytic action set up by lime compounds in the coke. Following up this theory, he next established the fact that if carbon monoxide reacts upon lime in the presence of water it will, under certain conditions, be converted into hydrocarbons and carbon dioxide. Accordingly, with a product such as blue water-gas the carbon monoxide may be almost wholly replaced by a hydro-carbon. When, moreover, it is realized that the calorific power of methane is rather more than three times that of carbon monoxide, the importance of the reaction becomes evident, although methane, *per se*, is practically devoid of illuminating power.

Vignon proposes to avoid the production of coke by gasifying the whole of the carbon of the coal. The idea is, of course, by no means novel, for in this country the "double gas" system and in Germany Prof. Strache's plan have both aimed at the same object, but have not met with any great success owing to the inferior nature of the gas (with a calorific value of about 380 British thermal units) which they produce. The beauty of Vignon's process, however, lies in the fact that by introducing a catalytic action he ensures a product having a carbon monoxide content not exceeding that of coal-gas, while the calorific power of the gas may be so much as 510 British thermal units. His method of working is, primarily, to carbonize a mixture of coal and lime at the moderately low temperature of about 1,650 deg. Fahr., this yielding a rich gas to the extent of about 8,800 cubic feet per ton of coal. The residue is then maintained at a temperature of 1,850 deg. Fahr., when a further yield of lower quality gas equal to 70,000 cubic feet per ton of coal originally employed is obtained. From the point of view of gas "makes" it will be seen, therefore, that M. Vignon easily leads the way. Even more surprising are his results in connection with ammonia recovery. Owing to the lowered temperature of the first stage of the process some increase of this compound, which is unstable at high heats, would be expected; but the actual quantity obtained is far in excess of expectations, and amounts to an equivalent of nearly 80 pounds of sulphate of ammonia per ton of coal, or exactly three times the quantity obtained in everyday practice. The question of ammonia is particularly interesting, in that in cases where the liming of coal as ordinarily practiced in this country has been in force there has always been claimed, among other things, an increased yield of the by-product. Although our knowledge as to the conditions prevailing inside the gas retort is limited it would seem that the lime in this case must act catalytically, accelerating the formation of ammonia or preventing excessive decomposition.

As is well known, catalytic action plays an important part in the latest methods introduced for eliminating carbon disulphide from coal gas. The principle, however, was in reality employed in the purification of gas some years ago, when the removal of sulphuretted hydrogen by means of oxide of iron was first conceived. In this process the net result achieved is the combination of sulphuretted hydrogen with oxygen to give free sulphur and water, the oxide of iron (after revivification) being retained in its original condition. Strictly speaking, this is not true catalysis, for the operations of fouling and revivifying the spent oxide are performed in two stages. In these circumstances Lessing has denoted the reaction as "protracted catalysis," but he is careful to point out that when a measured quantity of air is added to the gas so that revivification takes place *in situ*, then something approaching very near to a true catalytic action is set up. Certainly the process is not continuous, for the free sulphur after a time masks the surface of the oxide so that a situation akin to the well-known effect of catalyst "poisoning" is arrived at.

In Dr. Carpenter's process for the removal of carbon disulphide catalytic action is primarily introduced for the purpose of increasing the velocity of the reaction whereby this impurity is caused to unite with a portion of the hydrogen in the gas with the formation of another, but easily removable impurity. High velocity of reaction is one of the essential features of the process owing to the extremely small proportion (about 40 grains per 100 cubic feet, or 0.03 per cent by volume) of the undesirable compound which is present. The success of the whole operation may be attributed to the discovery of a catalyst effecting rapidity of reaction at a practicable working temperature.

During the last year or so the trend of chemical invention so far as gasworks are affected has been largely based upon the use of catalysts. For instance, the scheme of Guillet for removing carbon disulphide by employing iron catalytically is well known. The manufacture of synthetic ammonia is effected by bringing about the combination of hydrogen and nitrogen under high pressure in the presence of a catalyst; while in the most recent process of all, namely hydrolysis, by means of which cyanide compounds are converted into ammonia, thiocyanic acid is caused to react with water in the presence of sulphuric acid, which may be said to perform the function of a catalytic agent.—*London Times Engineering Supplement.*

Red Color of Faint Stars

In Contribution No. 81, from Mount Wilson Observatory, as published in the *Astronomical Journal*, F. W. Sears considers the colors of faint stars. During recent years there has been an accumulation of evidence that the faint stars are, as a class, appreciably redder than the brighter objects. Support has been given to this view by photographs taken at Mount Wilson with red and blue filters. A good foundation for the study of this question is furnished by the determination of the photographic scale of North Polar sequence, one of which has been made at Harvard, the other at Mount Wilson. With the exception of a divergence of about 0.4 magnitude between the sixth and tenth magnitudes, their agreement is very satisfactory. It remains to complete the scale for the visual values, and this has been attempted at Mount Wilson by the photographic method, using isochromatic plates and a yellow filter. The observations for the color indices are collected in a diagram showing their distribution for the region of the Pole. As regards spectrum, it is found that in cases where the absolute magnitudes are known there is a rapid increase in spectral type with increasing absolute magnitude. Whether this feature is due to an actual change in spectral type for the various groups of stars, or whether it is related to the intensity distribution of the continuous spectrum, cannot be yet decided. The presence of an absorbing medium in interstellar space would account for the fact, but this has not yet been definitely established.

The Nature of Ball Lightning*

A Curious Phenomenon, and Attempts to Explain Its Nature and Action

By Dr. Karl Wolf

THERE hardly exists a more curious, mysterious and interesting phenomenon than ball lightning. Attempts to explain it are usually timid and circumspect; indeed one gets the impression that it is quite inexplicable, while men of science are even reluctant to admit its existence. The latter can, however, no longer be doubted, in view of the amount of well-attested evidence adduced in its behalf; the reports often show such surprising agreement in details, even between different occurrences of the phenomenon, that we can feel sure the descriptions are reasonably accurate.

In the following discussion I shall not take up the well-known attempts of Planté and F. von Lepel to produce ball lightning artificially, as, in my opinion, misleading secondary phenomena are too likely to come into play in these experiments; moreover, the observational data in connection with the natural phenomenon are much more abundant and, therefore, more favorable for investigation.

The characteristics of ball lightning which are helpful in an investigation of the phenomenon are comprised in the following points, as obtained from well attested observations: Size, form, color, accompanying phenomena, state of the weather, character and location of movement, behavior with respect to other objects, velocity, distant effects (heat), mode of origin and dissolution, intensity and distribution of light, effects on objects touched, and noise of motion.

Recent reports of the occurrence of ball lightning are so numerous, circumstantial, and trustworthy that earlier observations may be ignored. As to size, the data range from a diameter of 4 inches to one or more than 6 feet; but in the latter case the reports emphasized the elongated shape of the object. It is probable that a diameter of a foot and a half or more is rare. In this statement account is not taken of a tail-like extension sometimes reported, and compared to the fuse of a bomb. In indications of size a child's head, a ninepin-ball, or a dish is often mentioned.

As to shape, the descriptions are so various that we might well hesitate to apply the term "ball" to the phenomenon. Besides the globular form, we find the shape compared to that of a heart, a pear, a balloon, an almond, an egg, and an aster; moreover, changes of shape during the passage of the phenomenon have been reported, in which cases we may suspect that the shape depended upon the observer's angle of view or varied on account of the turning of the object in its transit. One observer described the shape as that of a cat doubled up in a ball and advancing without moving its paws.

The colors are generally reported as fire-red, reddish, pink, reddish yellow, yellow, yellowish, bluish, or violet, the intensity of the color increasing from the center toward the border. The principal colors are red and bluish. There is striking unanimity as to the fact that a characteristic noise accompanies the phenomenon. This is variously described as buzzing, humming, hissing, whizzing, sizzling, whistling, etc.

At the time of this suddenly appearing phenomenon the atmosphere is always charged with electricity, often in a very marked degree. It may occur when a distant thunderstorm is in progress. As to the weather, it may be hailing, raining, or storming, or, again, clear, though the latter is rarely reported. The phenomenon may occur by day or by night.

It is very probable that in all cases a flash of linear lightning precedes the appearance of ball lightning. It has, indeed, in some cases been seen to arise directly from linear lightning; while in other cases luminous points—i. e., detached sparks analogous to ball lightning—have been observed to form the final product of ramifications of an ordinary lightning-flash. However, it is also seen to appear suddenly on the gable of a house, a lightning rod, the top of a mast, or some other elevated point; while in many cases it appears, apparently from nowhere, in the air, and immediately begins moving.

In the choice of its path ball lightning behaves in a very contradictory manner, sometimes performing the most incomprehensible turns and jumps. In one case it will slavishly obey a metallic conductor, such as a lightning-rod, wandering slowly along it; in another case it will appear to sport with the conductor, or pay no attention to it. It will follow the ridge of a roof; pursue a most tortuous course, or go straight ahead, roll over the ground at a certain height above it, collide with objects and rebound, and bounce up and down as if made of rubber. It penetrates obstacles and comes out on the other side; squeezes through chinks and keyholes and reappears, apparently unaffected by the process; it goes up or down chimneys; it floats lightly in the air like a toy balloon; it advances against the wind, or again obeys the least gust of the latter. It passes through tiles or bricks, leaving a hole behind it; moves through several rooms of a house; in short, its movements seem to be altogether eccentric and unaccountable. It moves cautiously, like a cat, among human beings, and likes to linger on points, corners, and angles. At times it halts in its course, or moves backward; accelerates or retards its speed.

In some cases the ball of lightning disappears quietly, while in others it explodes with a terrific noise, shooting fiery sheafs like the rays from a skyrocket in all directions. Again, the ball may resolve itself into a string of bead-like sparks. Ball lightning is rarely destructive or harmful to neighboring objects. No sensible radiation of heat from it has been reported. If these wandering balls come in contact with the human body, however, they may produce wounds and cramp-like sensations at the points of contact. A smell of sulphur is often reported and is sometimes said to be stifling in intensity. This may probably be ascribed to ozonized air.

It may be regarded as certain that ball lightning is the result of strong electrical discharges, and it must,

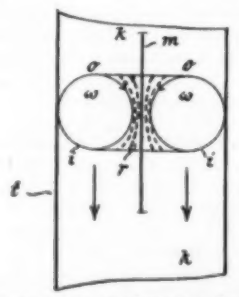


Fig. 1.—Vortex ring of electrons formed in the lighting channel. (Vertical section.)

therefore, consist of electrons, which would manifest themselves by their ability to fuse a conductor carrying an electrical current. If, however, the so-called ball is filled with electrons the latter must be in rotation; otherwise their collisions would soon break up the ball. The shape of the phenomenon cannot be really globular, notwithstanding the fact that many persons—whose surprise or terror impaired the accuracy of their observations—have so described it. Assuming a rotation of the electrons along their individual paths, the spherical shape would be quickly deformed, and if we assume a rotation in one direction around one and the same axis, the shape would become that of a vortex filament.

If in the neutralization of atmospheric potential between clouds and earth the number of atmospheric electrons is so great that they do not all unite with electricity of opposite sign, the surplus electrons will move to the walls *t* (Fig. 1) of the air-channel *k*, made by the stroke of lightning, as happens in the abrupt and intermittent action of a steam-jet, in such a manner that each particle of electricity will describe a circle (or actually an elongated ellipse) from the wall *t* by way of *o*, through the axis of the lightning channel, which thus becomes also the axis of a vortex ring of electrons *wow*.

At the point where the lightning channel ends—e. g., on a mast, a wire conductor of some kind, a lightning-rod, or in the free air—this vortex ring of electrons emerges from the channel and continues its journey, at first in the direction of the original lightning path, but later along a path determined by the wind or by such obstacles as may be encountered. Once the vortex ring is out of the air-tube in which it was formed, all the astonishing turns, passages through obstacles, glidings along the latter, jumping up and down, etc., observed in ball lightning may be explained by the fact that we have before us a ring *wow* practically free from air, filled with electrons, produced by rotation, and maintaining its form, but the electrons in which are gradually reduced in number by being thrown off into the surrounding air. The diameter of the phenomenon as a whole must be assumed to be greater than it appears to our eyes. In its passage through the air it has to push aside the air-molecules it encounters, and this corresponds to a certain consumption of energy.

Let us now follow the course of an electrified vortex of this character from the time it leaves the air channel until it is dissipated, and let us first see what happens when it encounters a wall or wire conductor.

Let us suppose that the energy of propulsion imparted to the ring at its origin is exhausted, and let us ignore the wind as a motive force; what force determines its further progress? To assume that it obeys a potential gradient in the atmosphere would be inconsistent with what has been observed regarding the movements of these phenomena. The ring must, therefore, move in consequence of some internal force, and this is probably the reaction effect of the electrons shot out from the axial tube (*r*, Fig. 2) of the ring. The electrons

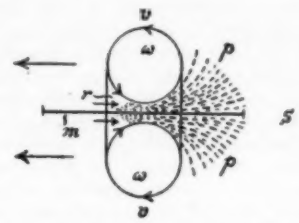


Fig. 2.—Hypothetical form of the lightning vortex when passing through the air.

passing, in their rotation, in the direction of the small arrows draw the air in the same direction in the channel *r*, so that the ring itself must force its way in the opposite direction. It is obvious that the air sucked in, in this manner, will make a hissing or whistling noise, such as we can reproduce by sucking air into the mouth. Moreover, the air molecules sucked in as described must be broken up into electrons by the impact of the rotating electrons of the ring and show a certain amount of light, which will be strongest in the direction of the emerging electrons and will gradually diminish on the sides *p p*. Again, as the luminosity due to the electrons shot off from the outside of the ring also diminishes with the distance from the ring, the reports of ball lightning in the form of a heart, pear, almond, etc., or like a bomb with a fuse, are by no means incomprehensible.

Now suppose the vortex ring meets a solid wall in such a position that the point of the ring (*s*, Fig. 2) is turned away from the obstacle. The result will probably be a to and fro motion, as the air drawn into the ring drives it to the wall, while the impact of the rotating electrons on the outside of the ring tends to drive the latter in the opposite direction.

Suppose, on the other hand, that the vortex ring is carried contrary to its natural direction of movement by the wind and meets the obstacle with its point of discharge toward the latter, the electrons issuing from the core of the ring will have the irresistible, destructive effect of a blast-lamp, and if the obstacle is not too solid will bore a way through. If the central axis *m* of the ring and the surface of the wall are parallel at the time of contact, the ring will probably tend to move under the effect of the reaction of the electrons thrown off tangentially at *v;* but the movement will actually depend upon whether this reaction effect is stronger that the suction effect at the center of the ring, tending to move it in the opposite direction. Evidently, if the ring is forced to move backward by this process, it will assume a leaning position, and the consequences of its assuming such a position help to explain some of the curious twists and turns of ball lightning.

As to the encounter of the vortex ring with a wire not carrying an electrical current, two principal cases will be considered. A wire carrying a current need not be taken into account here, as the problem would be complicated by the heating effects of the electrons.

Let the ring meet the currentless wire *D* (Fig. 3) in such a manner that the axis of the wire and the axis of the ring are perpendicular to each other, so that the ring meets the wire with its frontal surface. In this case the ring may rebound from the wire or pass right across it, according to the energy of motion it possesses. If, however, the ring as it approaches the wire has its axis parallel to the wire, it will be penetrated by the latter until the wire coincides in position with the axis of the ring (Fig. 4). Once in that

* Translated from *Prometheus*.

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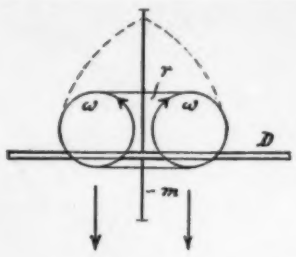


Fig. 3.—Vortex lightning crossing a wire.

position, the ring remains held there, for any movement to one side, e. g., under the influence of the wind, brings into play the suction effect of the electrons in the interior of the ring, which at once restores the latter to its central position. The ring now obeys only the reaction of the streaming electrons on the wire and the sucked-in air, and these forces move it along the wire in a direction opposite to the motion of the electrons on the inner side of the ring.

The fact often reported that so-called ball lightning appears to soar along the ground at a certain elevation above the latter is easily explained on the assumption that the diameter of the vortex ring is actually greater than it appears to be, because the thin, faint marginal portions are invisible, but electrons are nevertheless present in sufficient numbers to insure the propulsion of the ring over the ground.

The electrons must rotate very rapidly. This may be inferred, in the first place, from their velocity in the lightning channel *k*, and secondly from the fact that the surrounding air molecules cannot penetrate the periphery of the ring. Air molecules are, indeed, continually sucked through the center of the ring and ejected on the other side, and this probably explains the hissing or whistling noise so often heard. An actual ball of electrons could not produce this noise. We will now be less surprised that the ring of electrons passes with impunity through holes and crevices; as the whole assemblage of electrons, which takes its way through the central axis, can stretch out into so slender a filament that even a key-hole need not be an obstacle to its passage. In case the ring encounters conductive, currentless material of sufficient mass, its rapid absorption is very probable.

The walls of the ring must be so thick and so well protected by the rotating electrons that the vacuum *w*, originally formed in the lightning channel, will persist for a considerable time. With the continual loss of its electrons—i. e., with the thinning of the ring wall *i* on account of the separation of electrons under centrifugal force—the wall becomes weakened at some point until it can no longer resist the pressure of the surrounding air, which enters and bursts the ring from inside outward, like a broken electric light bulb. The energy of the explosion is so great as to render luminous the air molecules struck by it.

A flash of linear lightning has sometimes been seen to resolve itself into a number of luminous balls. This can be explained on the assumption that several emissions of electrons occurred from the lightning path. Moreover, it is probable that balls of electrons sometimes break out at sharp bends in the path of a lightning flash, and pursue their way as vortex rings.

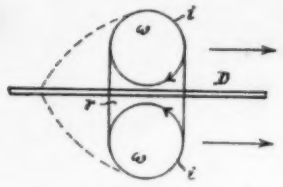


Fig. 4.—Vortex lightning gliding along a wire.

We may summarize the principal points of our hypothesis as follows:

So-called ball lightning is not altogether appropriately named. It is probably a vortex ring of electrons, and might better be called "vortex lightning." It consists of surplus electricity, and receives its form in its passage through the air-channel or tube made by a flash of ordinary lightning, like the steam vortex-ring produced by an intermittent steam-jet. Its devious wanderings can be explained as the result of the rotation of its electrons and the effect of this rotation upon obstacles. Its sudden, explosive destruction or its tranquil dissipation will follow, respectively, from the sudden or the gradual entrance of air into a vacuum. The whistling or hissing noise of such lightning probably arises from the sucking of air through the central orifice of the ring, and the same process explains the normal motion of the vortex ring. The gliding of ball lightning along a wire occurs when the position of the wire coincides with the central axis of the ring. The luminous tuft or projection often reported can be explained as an extension of luminosity due to the electrons streaming from the axial orifice of the ring.

Ammonia a Heat Vehicle*

A Popular Explanation of the Refrigerating Process

By Albert Johnson

Let us see how anhydrous ammonia becomes a conveyor of heat. When one pound of anhydrous ammonia has passed through the regulating valve into the low-pressure pipes it remains a liquid until it can grab hold of from 500 to 600B.t.u. of heat. Then the pound of liquid changes into a pound of gas. But it refuses to change from liquid to gas until that much heat leaves the room and enters the liquid ammonia on the inside of the coils, thereby turning it into gas.

The changing of the liquid into gas is what absorbs the heat. Therefore, it is always necessary to have plenty of liquid ammonia within the low-pressure pipes.

Do not, under any circumstances, allow gas to pass through the regulating valve, for then you only add heat to your rooms instead of subtracting it. Remember, the gas is the loaded vehicle, while the liquid is the unloaded vehicle, being empty. The liquid has plenty of room for heat units, but the gas has little room for heat units, since it is already loaded with them. It cannot carry any more. So it is well to watch and see that only liquid passes the regulating valve into the low-pressure pipes.

This is a more serious question in operation than you may think possible, and the subject is more fully covered in my former paper read before the International Congress of Refrigeration, and entitled "The Value of a Liquid Seal," which can be had upon application, free of charge.

Bear in mind that it requires heat to vaporize ammonia—the more heat, the quicker the evaporation; whereas, the less the heat, the slower the evaporation, which explains why "sharp freezers" are so apt to fill up with liquid in abundance, while the rest of the system may be suffering from the lack of liquid.

After the liquid has been changed into vapor by the heat, it has practically spent its energy as a refrigerant, for the gas has obtained its full load of heat and is ready to carry it away.

So far the ammonia, or vehicle, has been "running down hill," requiring no power. At the bottom of the hill is the loading platform where the heat is taken aboard. After this it's an uphill pull, and a good strong horse is required to pull it up to the unloading platform. The horse may be called a "refrigerating machine."

The machine gets behind the heat-laden gases in the frosted low-pressure pipes and pushes them up to the top of the hill to the unloading platform, or ammonia condenser, where the loaded gas is changed back into a liquid. Just at the moment when the gas becomes a liquid it releases or dumps out the heat that it formerly picked up in the rooms, and the water in the condenser then absorbs the released heat units and carries them away.

Thus we see how necessary is the refrigerating machine to push the loaded vehicle, ammonia, along the uphill grade of high pressure direct to the top, or unloading place, at the condenser. But that is all it has to do, for the real work of freezing is performed by the ammonia, not by the machine. The initial as well as the final operation is done by the vehicle called ammonia, which must not be forgotten.

Thus you can readily see how anhydrous ammonia actually becomes a so-called vehicle for removing heat units from insulated rooms and carrying them, with the aid of the refrigerating machine, upstairs or downstairs, around corners and angles to condensers, there to unload its heat. Then it goes back to repeat the operation.

A regulating valve controls the flow of liquid ammonia into the low-pressure pipes. That is all it is there to do. It cannot do any freezing, since only the ammonia does that. I mention this because, way back in the early days of this industry, somebody misnamed that valve—the expansion valve—without thinking of the consequences.

Ever since then many operators got the erroneous idea that this valve actually did the heavy work of freezing, and they would fondle it and handle it, fuss over it and play with it, sometimes resetting it twenty times a day, then listening to hear the gas gurgle or spit through it. The misnaming of this valve has cost the owners of plants hundreds of thousands of dollars in time lost fooling with it and in lack of efficiency caused by relying on this valve during critical moments of climbing temperatures, when the receiver should be watched instead. It is best to call it a regulating valve, to save confusion of ideas, much money and false impressions.

When I speak of heat-laden gases in suction pipes it may surprise you. Try to put your hand on a frost-covered suction line and imagine it contains real heat. It actually does, and lots of it, only it is called latent heat, or insensible heat. A thermometer cannot register it, nor can you feel it by touch. But it is there just the same. Apparently, the pipe is very cold, for it is usually covered with frost, yet the cold gas inside of that pipe will deliver heat enough to warm up enormous quantities of condensing water from 10 deg. to 30 deg. Fahr. per pound.

We learn how the vehicle ammonia is relied upon to take the initiative in the work of removing heat. It is essential to work with not only dry, but pure ammonia. Note the difference between dryness and purity, for volatile hydro-carbons may exist in the liquid itself, which cause abnormally high pressures. Such foul gases refuse to liquefy and they fill up the condensers.

These bad gases must be blown away. Hydro-carbon gases are both colorless and odorless, which makes them hard to find. They are hidden, and like latent heat we know them by the effect they produce when they refuse to liquefy, causing excessive fuel bills or power bills and great ammonia consumption.

It has been estimated that in order to purge 15 pounds of uncondensable or hydrocarbon gas from the system you lose 85 pounds of pure gas, because the two are closely associated or intermingled, so that when the purge valve is opened the good as well as the bad gases are liberated unavoidably together.

Good Ammonia Requires no Purging.

Good ammonia requires no purging, for good ammonia is free from volatile hydro-carbons. The evaporation test does not disclose the presence of volatile carbon compounds, for they evaporate together with the ammonia. The working test seems to be the most reliable. The test for air in shipping cylinders means little as to quality and has the disadvantage of being deceptive.

Ammonia is like fullers' earth, because both require a working test to prove their effectiveness. In both cases results count more than analysis. A chemical report on fullers' earth is about as valuable as a chemical report on anhydrous ammonia. However, in making an exhaustive examination of ammonia a thorough chemist will demand to see the raw material as well as the finished product. In testing cement, for instance, a thorough chemist will also examine the clinker or raw material as well, in order to obtain data for proper valuation. The clinker may be overburnt or underburnt, and the chemist is right in demanding a sample of the raw material.

The purchase of anhydrous ammonia should be like the hiring of a man. You expect a man to perform some service and keep on doing so. In purchasing ammonia you must expect it to serve you by picking up or absorbing all the heat units possible and unloading them in large quantities day by day, without getting tired or worn out on the slightest occasion. Remember, you do not buy ammonia like other merchandise, to be sold to others from the shelf. Instead of that, you invest your money in an article that must work for you day and night, and produce results in heat-carrying capacity. For, to produce one ton of refrigerating duty the vehicle, ammonia, must fetch and carry away 288,000 B.t.u. of heat from insulated rooms in the shortest time possible, and that is why the question of ammonia as a heat vehicle is so serious as to affect the profits in a refrigerating plant.

* A paper read before the American Meat Packers' Association.

The great turtle, which was molded by the glue process in fifteen days. Maudslay's plaster piece mold required three months, and 600 pieces.

Forms for casting the great turtle. The first series of forms reaches to the workman's foot, the second to his waist, and the top was in two pieces.

Reproducing Prehistoric Monuments

Valuable and Clever Archæological Work at Quirigua, Guatemala

By Neil M. Judd

THIRTEEN visible stone monuments with the ruins of surrounding temples, pyramids, and ceremonial courts are all that remain of a once powerful religious community near the present station of Quirigua, Guatemala. Sixteen hundred years ago, if we may accept the figures of some students of Central American archæology, this empty city was active with the enthusiasm of its inhabitants; now the call of jungle fowl echoes through the enveloping silence.

In an effort to preserve this home of a prehistoric people the United Fruit Company has recently created a reservation of seventy-two acres, thus separating from its enormous banana plantations a ruin the very existence of which remained unknown until 1840. During that year Mr. John L. Stephens, bearing special messages from the United States Government to that of Guatemala, heard of the old city and sent his companion, Mr. F. Catherwood, to view the site. Mr. Catherwood's sketches, accompanying Mr. Stephens' descriptions, introduced the Quirigua ruins to students of archæology.

Forty-one years later Mr. A. P. Maudslay, an English traveler, visited the ancient city. He secured hurried notes and photographs, but returned for more detailed observations during each of the two following years and again in 1894. While continuing his investigations of 1883 and 1894, Mr. Maudslay secured paper squeezes and plaster piece-molds of several of the huge carved stones for which Quirigua is so justly famous. Subsequent American expeditions added to Maudslay's list of molds, notes and measurements, but a systematic study of the Quirigua ruins had not been attempted, I believe, until Dr. Edgar L. Hewett, Director of the School of American Archæology, began a series of excavations in January, 1910. With one exception, these excavations have been continued annually since that date, and during the expedition of the past winter, the most recent of the series, I was a chance associate, having in charge that phase of the work which these paragraphs consider.

As a former religious center of the Maya Indians, the old city of Quirigua consisted of a principal temple area, a large ceremonial court or plaza, and a number of associated temples and pyramids. The dwellings of its devotees were, supposedly, mere palm shelters scattered through the forest-covered valley for some distance beyond the priests' houses.

Mother Nature and all the little elements at her command have been working for generations in their attempt to erase evidence of man's invasion of the Quirigua jungle. Dripping water and swaying branches have cut and grooved the monument surfaces; earthquakes and growing plants have broken and split the heavy stones, thus destroying, to a greater or less extent, the lines and carvings with which they were all decorated. When Maudslay first visited Quirigua, in 1881, the ruins were almost hidden by a dense forest; the sculptured stones were overgrown with a mat of vines and moss in which even large trees had taken root. This growth was removed at that time for photographic purposes, but, owing to the tropical environment, the cleaning had to be repeated when the School of American Archæology began its work and again when the recent expedition commenced operations in January of last year. The possibility of irreparable damage has rather hastened a realization of the necessity as well as desirability of reproducing these sculptures.

The stone monuments at Quirigua are of two types: tall stelæ or shafts, with human figures carved on both faces, and hieroglyphic tables on the shorter sides, and low, zoomorphic stones bearing similar inscriptions along the sides or front of the animal forms. Each stone was originally erected at the end of a Hotun or five-year period and its hieroglyphic inscriptions undoubtedly commemorated the important community events during that interval previous to the one in which the stone was raised. From an archæological point of view, these monuments are valuable not only as examples of prehistoric American sculpture, but also as records whose text may some day be intelligible to us and aid materially in broadening our meager knowledge of the people who conceived them.

Each monument was cut from a solid block of scoriaceous sandstone; that is, the stone consists mostly of volcanic scoria, but also contains quantities of sand and coarse gravel. The action of the elements has loosened many exposed pebbles from their silica cement, thus adding small pittings to the already rough, granular surface and increasing the difficulties of mold-making by resisting all efforts to force an inflexible substance into perfect contact with the surface of the stone and by tenaciously gripping that substance, once it had been properly driven into position. For such a superficial texture, glue proved the ideal agent since the material of the molds was placed in a liquid condition and its natural elasticity, when hardened, permitted great distortion in removal.

Our process of mold-making was very simple. We began by building a light plaster foundation around the base of the monument. This not only prevented the escape of the melted glue, but also supported the superimposed forms which served as retaining walls for the glue molds. Above the foundation a given section of the stone was covered with a layer of common clay mud, approximately 1 inch thick. Over this a carefully jointed plaster form was built, of such dimensions as the breadth of the monument and the depth of its carving required. On the larger stones the size of the forms were often limited by our ability to handle them —lacking mechanical means of moving heavy masses, we seldom made forms in excess of 15 square feet.

During the construction of these forms wooden braces were built into them and anchored with ties of fiber. Such supports increased the strength of the forms and, in addition, their extended ends proved a convenience in handling. Each form was completed, allowed to set, and its edges trimmed before an adjoining form was begun. Upon the completion of the four forms composing each section all joints were secured with temporary ties of hemp and the working platforms raised for a second series.

In this manner the whole surface of the monument was covered and then, commencing with the topmost form, we began the real process of mold-making. One complete, horizontal section was lowered each day, the subjacent layer of clay thrown aside, and the exposed stone surface thoroughly scrubbed, to remove what mud and lichenous growth still adhered. While the stone was drying all irregularities on the inside of the four forms were scraped off and the surfaces painted with a thick coat of clay-water as an aid in separating form and glue mold.

At the same time glue tubs were placed over hot water baths and their contents made ready for the daily pouring. That section of the monument to be reproduced and the inside surfaces of the waiting forms were thoroughly oiled with a composition composed of stearine, kerosene and vaseline; the forms were raised to their original position and all joints were tied and covered with plaster and hemp. In their "original position" the forms were separated from the monument by an interstice equal to the thickness of the layer of clay over which they had been built. That space which the clay had occupied was later filled with melted glue. The thickness of the resulting glue molds, therefore, depended upon the thickness of the layer of clay they replaced. A section of the plaster form supported the back of each mold the face of which reproduced, in intaglio, the lines and carvings of the monument. From this counter-sunk glue impression the cast was later taken.

Those receptacles in which the glue was melted were ordinary galvanized iron wash tubs. Two sizes were employed, one containing the glue and a larger one in which the first tub might be placed, the two being separated by three or four small stones and a quantity of boiling water. The outer vessel rested upon metal rods or pointed stones, leaving space for a fire underneath; the water it contained was kept at boiling heat until the glue had thoroughly melted, after which it was ready for the forms.

Pouring the glue was a simple matter and required only a number of pails and men to pass them. Since the normal glue mold shrunk considerably in solidifying, we increased the width of the forms by adding a low rim of plaster to the top of each section and, by filling this enlarged form with glue, secured a slight over-lapping of the glue molds. This enabled us to trim them flush with the original edge of their plaster forms and assured perfect joints when the casts should be finally assembled. Through those forms that inclined from the perpendicular air-holes were drilled and later closed with clay as the liquid glue, rising in the mold-space, began to flow from them. Improvised funnels were sometimes used in filling the glue-space, the weight of the liquid remaining in the funnel forcing possible air bubbles out of the glue molds and also counter-acting the effect of shrinkage along the upper edge of the mold.

Glue molds must be thoroughly cooled and hardened before plaster casts may be taken from them. To better obtain this condition our molds were usually poured at sundown and left undisturbed until daylight. Then, as quickly as possible, the forms were lowered and the glue molds prepared for casting. Great care was taken to protect these molds from even the early morning sun since only a few moments' exposure served to soften and melt-down the impression.

The surfaces of the glue molds were first dusted with French chalk to remove any adhering grease. After this a saturated alum solution was carefully brushed into every pore of the mold surface. On an average, one hour passed before this solution had completely evaporated, but it always left a thin coating of alum that hardened the glue surface and protected it materially

Cast from upper right corner of the great turtle.

Cast of death's head from monument.

On the left is shown one of the taller monuments compared with a six-foot man. On the right two of the larger monuments. The one leaning is twenty-six feet long.

from the heat generated by the setting of the plaster composing the casts. This alum-hardened surface was painted with a thin stearine-kerosene oil previous to casting.

Our casts were made in the usual manner, that is, the face of each glue mold was covered with liquid plaster and this was added to until a desired thickness had been obtained. During the construction of the casts each was carefully reinforced with wooden braces and hemp fiber to prevent warping and breaking.

Each horizontal section of the reproductions of the stelæ or upright monuments was composed of four parts, one for each side of the stone. These four parts, with their glue molds and supporting plaster forms, were usually bound together and braced from the inside before being separated from the glue molds. Since all plaster forms were constructed in conformation to the outline of the monument they reproduced, their corner joints were known to be exact, therefore by carefully joining these forms and, while so joined, uniting the four parts of the cast they supported, the angles of the reproduction became as accurate as those of the original. Any other method would have required numerous measurements and much care in using them. Uniting the casts as we did necessitated merely uniform setting of the plaster on the four glue molds and a reasonable amount of speed in joining the casts. Even with our alum solution the heat of the setting plaster soon melted the glue molds.

Each morning, as soon as the cast had been completed, attention was directed to preparations for the mold that was to follow. The forms were lowered from the next section on the monument and the stone prepared as indicated in preceding paragraphs. The glue molds just used were cut into small pieces and spread for drying; the forms were destroyed and carted into the jungle. It is interesting to note that melted glue, left in pails or tubs, would neither cool nor solidify, but deteriorated within a few hours. Also, if the drying fragments of the discarded glue mold were carelessly spread and a free circulation of air prevented, they invariably sweated and soured, rendering them unfit for further use.

Our party entered the field with no experience and but little knowledge of the use of glue molds. During such preliminary experiments as we could conduct while awaiting the arrival of our materials, we learned that, in the tropics, glue or gelatin molds required more careful preparation than in the States. Our first pourings were too thin and resulted in soft, rather sticky molds. It was soon apparent that a mere dampening of the dry glue flakes gave a thicker, heavier pouring and a more satisfactory mold than was possible with well-soaked gelatin. The impossibility of obtaining cool water for casting also brought its difficulties—speedy work was our only means of overcoming the resulting inconveniences. Another vexing problem was met with in the drying shed, where minute worms developed a habit of exploring the interior of our plastic casts. Denatured alcohol, applied, to the plaster, seemingly increased their prodigious appetites, for they continued to honeycomb the casts unless each reproduction was frequently exposed to the direct rays of the burning sun.

The climate was, of course, the greatest handicap under which the expedition labored. We reached Quirigua at the beginning of the dry season, a ninety-day period during which the rains are more irregular and of shorter duration than usual. Temperatures were distinctly tropical, a fact that only increased our troubles. Under such conditions not only the nature of our medium, but personal comfort as well, required a temporary shelter over the monument being cast. Accordingly, canvas tarpaulins were drawn over poles that reached above the stones, drop-curtains being utilized when driving rainstorms or the afternoon sun threatened the exposed parts of the monument.

During February, March and April, the three months during which records are available, the average daily temperature was 66 degrees at 6 A. M., 88 degrees at 12 noon, and 76 degrees at 6 P. M. In the small, open space where our work of reproduction was pursued the temperature was obviously higher and more unbearable. The direct rays of the sun were unmerciful and the 150-foot wall of surrounding jungle successfully turned what occasional breezes would otherwise have freshened the plaza. A persistent, high humidity, added to this heat, was certainly a sufficient test as to the practicability of glue molds in the torrid zone.

For shipment, all casts were packed in wooden crates and protected by dried banana leaves. The fact that they survived the rough handling of Central American ports and reached New Orleans with very little breakage was owing to careful and generous reinforcement of the casts rather than abundant packing.

Our work was continued over a period of four months, during which time casts were made of six colossal monuments. Each of these reproductions is an exact duplicate of its original and exhibits not only every line and carving of the primitive sculpture, but the very texture of the stone itself. Compared with the results obtained by other processes, the casts from our glue molds are so vastly superior as to beggar description. The completed reproductions are to be installed at San Diego, Cal., during the coming Panama-California Exposition and later removed to the halls of the School of American Archæology at Santa Fe, N. M., for permanent exhibition.

Building up the forms.

Good Water for Farm Homes

CLEAR, sparkling water is not always pure water. A refreshing draught from "the old oaken bucket" may be the beginning of a long and possibly fatal illness from typhoid fever, dysentery, cholera or other diseases.

The subject of pure water supplies for drinking and cooking purposes is discussed in a really valuable bulletin just issued by the United States Public Health Service under the title "Good Water for Farm Homes."

The germs of the so-called water-borne diseases come from the bodies of persons afflicted with those diseases. They do not live long outside the body and do not originate spontaneously in nature. A few diseases are communicated from animals to man, but for the most part the germs which get into drinking water and produce disease come only from human beings. If we keep the waste products from the bodies of human beings and animals away from our water supplies, we keep the water free from disease germs.

The usual sources of farm water supplies are wells, springs, and cisterns. Running streams are so seldom free from dangerous pollution that without purification they cannot often be considered safe for domestic use.

The most common form of supply is the shallow well, reaching into a layer of earth saturated with water. Few of these are fed by flowing streams, except in limestone formations, and they are really little more than reservoirs for "surface water." Since they drain the surface for a radius of sometimes several hundred feet, their location with reference to stables, out-houses and stock pens is a matter of prime importance. Other possible sources of pollution are a leaky or loose well casing, a defective curb, or a cover that is not watertight. The best methods of constructing such wells and protecting their contents are set forth in this bulletin of the Public Health Service.

Artesian wells, driven wells, cisterns and natural springs are also discussed in this publication, and safeguards against pollution prescribed. It is sometimes impossible to secure pure water for drinking and cooking, and methods of purification must be adopted. It should be borne in mind also that once a safe supply is obtained, its purity is insured only by the continued observance of the principles of common sense and common cleanliness. These are neither difficult nor expensive.

Trimming edges of a mold.

Future Methods Of Utilizing Coal*

Economic Problems That Are Beginning to Attract Attention

By Prof. C. F. Hirshfield

THERE is at the present day a certain amount of coal buried in the earth's crust. Coal is being slowly formed at some points on the surface of the earth, but the rate of formation is so slow in comparison with the rate of consumption that for all practical purposes the supply available for human consumption may be assumed to be that already formed. If this view is taken, it is evident that the amount of coal which can be used by man in the future is definitely limited; when he has used up the coal now in the earth's crust, or that part of it which he can extract, there will be no more available for use.

The estimates of the length of time which will elapse before this condition is attained vary greatly, but most of them allow humanity at least a few hundred years before the exhaustion of all available coal. Opinions as to what may happen when the time of ultimate exhaustion arrives are equally variable. Some believe that humanity must perish because of the enforced cessation of industries and because of the impossibility of keeping warm during the cold seasons of the year. Others believe that by that time hydro-electric development will have been carried to such a point that electrical energy will entirely take the place of heat derived from coal. Still others are satisfied to let the future take care of itself and to assume that the human brain is going to be able to continue to devise methods of changing the environment to suit the needs of the human animal.

I am inclined to take the last view myself, as I believe that the centuries of human history which are available show that each successive generation has become better able to force its dictates upon nature rather than to be subservient to the unrestricted action of natural forces. In other words, subsequent generations will be better able to care for themselves than the present generation and there is no need to waste good time and effort in trying to solve their problems for them with a smaller stock of knowledge and a narrower vision.

In taking this viewpoint it is not necessary to hold ourselves responsible to future generations for the use we make of the coal stores which we are depleting at such a rapid rate. We may consider ourselves free to use this material as our industrial development requires, though we are, in a certain sense, morally bound to make that usage as economical as possible on the basis of the general principle that it is not good economics to waste wealth of any sort.

If, then, we attempt to look into the future for the purpose of predicting the methods which will be in use for the utilization of coal, we must not warp our vision by an erroneous assumption of the necessity of conserving the supply. We must rather study industrial developments of the past and after discovering their general trend, attempt to apply this knowledge to the particular field under discussion.

It has been characteristic of nearly all industries that they started in a small way under conditions which did not require the most economical production. Thus the shoe industry was started by numerous individuals scattered over the country, who purchased leather, nails, thread and other raw materials in small quantities and then worked them up into shoes on individual orders received from people living in the immediate neighborhood. The modern packing industry sprang from the small butcher who slaughtered for local consumption and disposed of the hides and other byproducts in the easiest way possible. The clothing industry was originally confined to the home, the land or the live stock producing the raw material, which was worked up by the family of the owner into the clothing required by that family.

All of these industries have grown until they are scarcely recognizable as the offspring of their forebears. This has been brought about by organization, which is merely the combination of capital and the division of labor for the purpose of producing the biggest possible yield from given raw materials or natural supplies.

In the shoe industry scientific development produced the marvelous machines which are now used in producing leather and shoes and the railroads which later transport the factory-made product to the scattered consumers.

In the packing industry the refrigerator car made possible the concentration of the slaughtering industries and, coupled with mechanical and chemical invention, assisted in building up large modern plants.

Spinning and weaving machines, cutting, sewing and pressing machines, coupled with the railroads, have made possible the huge centralized clothing industries of the present day.

The study of the packing business tends to throw considerable light upon the probable future development of the coal industry. It is not so many years ago that, in this country at least, meat on the hoof was so plentiful that it could be slaughtered in most expensive ways and still be sold at a profit at such a low figure as to bring it within the reach of practically all families. Conditions are now different and meat on the hoof is comparatively scare. It therefore brings comparatively high prices and if all or practically all of the purchase price, transportation and slaughtering expenses had to be borne by the meat and hide, the prices of these commodities would be so high as to put them beyond the reach of many families even in this comparatively opulent country.

But the modern packing house manages to sell every part of the animal for some purpose. Some parts, such as those sold in the form of dressed meat, are disposed of after little modification, while others, such as horns, hoofs and fat, pass through elaborate manufacturing processes before they are ready for the market. When it is remembered that every one of the numerous products is sold on the average at such a price as to bear its share of the cost of the animal, of its transportation, and its slaughter and dressing, it is evident that the principal product, meat, can be sold at a lower price than would otherwise be possible. Moreover, waste has been reduced to a minimum; all parts of the animal which cannot be used for food are used for other purposes.

The coal industry, particularly in this country, is in much the same position to-day as would be a packing house which produced meat only. Coal is removed from the mine, put in marketable condition with the minimum possible expenditure and shipped to the consumer. The greater part of it is burned under boilers just as it is received or after breaking to smaller sizes

As the supply in sight in the ground decreases, as mines become deeper and as freight rates increase, coal becomes more and more expensive. This process must continue so long as the methods at present in vogue in the industry continue and the cost of coal must ultimately become a serious burden on industries in which the coal charge forms a large fraction of the total charge. In view of what has happened in other industries it is but natural to assume that when economic pressure makes it necessary, the coal industry or the methods of utilizing coal will be so modified as to obtain the maximum possible number of products with the maximum possible economic value from each ton mined, provided such products are obtainable.

We are accustomed to think of coal as merely so many stored or latent units of heat energy purchasable at so much per thousand or million. It is far better, however, to view it as a collection of chemical substances and combinations which are capable of almost an infinite number of transformations and recombinations to form innumerable new end products. If coal were merely a collection of units of heat energy the cost per unit would of necessity continue to increase until it reached a prohibitively high value. Taking the view just suggested, however, it is possible that chemical jugglery of the constituents may be made to develop substances marketable at such prices as to materially reduce the necessary selling price of units of heat energy.

The principal constituents of coal are carbon, hydrogen, oxygen, nitrogen and sulphur, and these are the blocks out of which innumerable organic and inorganic chemical compounds are built. Just how these various constituents will be liberated or recombined for the purpose of increasing the economic value of a ton of coal in order that the selling price of units of heat energy may be kept down to a reasonable figure, must be more or less a matter of speculation. It is, however, pertinent to note that processes of this kind are already in use in some of the European countries and particularly in Germany, and it is reasonable to suppose that future development will follow along some such lines as those already partially developed. An investigation of these methods may therefore assist in arriving at a more correct prediction of future methods.

In general, development is carried on along three lines: First, the thermal efficiency of heat engines and plants is brought to the highest possible figure in order to reduce to a minimum the number of heat units which must be purchased by anyone concerned in the generation of power; second, byproduct fuels of various varieties are made from the raw coal, or from the coal in the process of utilization and some of these may have such desirable properties as to be worth more per unit of heat energy than is the raw product. Their use or sale therefore tends to reduce the price paid for heat units in the raw coal. Third, many byproducts useful in numerous arts are made and their economic value helps to reduce the cost at which units of heat energy or their products must be sold to yield a profit.

It will be observed that when the coal-mining and consuming industries develop in this way, they begin to approach the condition of the modern packing industry. The capital involved is enormously increased; many more kinds of labor are required and the subdivision of labor is carried to a far greater extent; and the economic value of the product per ton of raw coal is enormously increased.

The parallel may be drawn still more closely. Meat for human consumption may be considered the primary product of the packing industry. The selling price is continually increasing, but the rate of advance is kept lower than it otherwise would be by increasing the number of products per unit of raw material, giving a greater economic value to the products per unit and reducing the charges against the primary product. Heat energy may be said to be the primary product of the coal industry and the selling price of this is continually increasing. The rate of advance is kept lower than it otherwise would be by increasing the number of products per unit of raw material, giving a greater economic value to the products per unit and reducing the charges against the primary product.

Development along these lines has thus far progressed along two principal paths. The raw coal is subjected either to a destructive distillation process with the exclusion of air, or to a process of incomplete combustion in the presence of air. The former method yields a solid fuel called coke; combustible gases of a more or less permanent nature; condensible vapors of great chemical and fuel value; and other substances, such as ammonia, cyanides, sulphur compounds and others. The latter method yields solid, incombustible refuse or ash of comparatively small value; large quantities of combustible gas of great value; considerable vapors which are becoming of greater chemical importance daily and are also becoming available as fuel; and small quantities of chemical compounds of more or less value.

By such means as these fuel material becomes available in solid, liquid and gaseous forms, and the particular variety best suited to any use may be chosen therefor if price permits. It is, of course, impossible to obtain more heat units than were originally contained in the fuel. There is in reality always a loss in these processes, but the thermal efficiency with which the smaller number of resulting heat units can be used may more than balance the thermal losses occurring during the modification of the fuel. Great developments have been made in the use of gaseous and liquid fuels during the past few years. It is now possible to use such fuels for the generation of steam, for industrial heating, and for the operation of prime movers at efficiencies much higher than seemed possible of attainment a short time ago. Surface combustion and the internal-combustion engine in its various forms are pointing out lines of development leading toward constantly increasing thermal efficiencies.

These statements must not be interpreted as an argument for the immediate adoption of gas firing and of the universal use of the internal-combustion engine. Other matters must be given consideration as well as the cost of fuel. The cost of capital is of equal importance.

At present the costs of capital and of fuel are both increasing, but the cost of the latter is increasing more rapidly than that of money. Even now the cost is such as to warrant greater capital investment for procuring greater thermal efficiency than could have been justified a few decades ago. Ultimately the cost of fuel must rise to such values as to warrant the investment of

* Abstract of paper read before the Detroit Engineering Society. Republished from *Power*.

the necessary capital and the training of the necessary labor to make possible the use of fuel in such ways as to produce the greatest economic production per ton of raw material.

When that time comes it is probable that coke, or something resembling it, will be the principal solid fuel; gases formed during the production of the solid will be used in internal-combustion engines, or by surface combustion, or in ways not yet discovered; and liquid fuels formed during the production of solid fuel will be used in high-efficiency, liquid-fuel engines. Before they are used the liquid and gaseous fuels will be robbed of many valuable constituents, which will be used in producing fertilizers, medicines, paints, dyes, preservatives, waxes, flavoring extracts, commercial chemicals and many other products yet undreamed of.

Summarizing these ideas, it seems probable that:

1. Improved or more economical methods of utilizing coal will not and need not be brought about by any consideration of conservation as now ordinarily understood.

2. Such methods will be brought about by cumulative economic pressure due to the natural operation of increased demand for fuel combined with decreased quantities and increased cost of mining and transportation.

3. When such methods are thus forced upon humanity they will follow, in a general way, the course developed in other industries under the force of similar circumstances.

4. These methods will consist of a preliminary treatment of the raw material to produce fuels with different physical and chemical characteristics which will adapt each form to use in particular kinds of apparatus or in particular industries.

5. Coincident with this treatment will be produced numerous non-fuel byproducts of great value in the then existing markets.

6. The spreading of the cost of the raw material over so many products will prevent the excessively rapid rise in the selling price of fuel per heat unit and this, combined with high efficiency methods of utilization made possible by the relative prices of fuel and capital, will yield the same sort of an economic balance as now exists. Humanity will probably then, as now, bemoan the fact that it could not have lived several generations before, when fuel was "cheap," and will probably express great sympathy for the coming generations that will have to face the problems of life with a still more depleted coal supply.

Many will probably object that the cost of modifying coal, as, for instance, by the destructive distillation process, has always been so expensive that little is to be hoped for along such lines in the future. In answer to such criticisms, it is only necessary to point out the fact that despite the rising prices of coal, labor and capital, the selling price of gas made by such processes has steadily decreased. It is admitted that further decrease cannot be brought about by exactly the same methods as have been used in the past, but it shows very little faith in the progress of the human race to assume that the present status in any industry represents the ultimate development of which humanity is to prove capable.

Formulas For Glass Manufacture*

THE Institute of Chemistry has given out an account of the work of the Glass Research Committee appointed by the council of the institute to conduct investigations with the view of arriving at suitable formulas for laboratory glassware, miners' lamp-glasses, combustion tubing, resistant glass for pharmaceutical products, glass for X-ray bulbs, etc. The main part of the report is here reprinted, and is of particular interest at the present time.

Since October, 1914, the research has been continued uninterruptedly, the chief aims being:—(i) to produce working formulas for all glasses used in laboratory work, and (ii) to ascertain the influence of various ingredients on the physical and chemical properties of glasses. The work was extended to include glass for miners' lamp-glasses, at the suggestion of the Home Office; and also glass for ampoules, to meet the needs of the wholesale pharmaceutical chemists engaged in the production of army medical requirements. The committee also examined and reported on samples of British and French laboratory glassware, produced since the beginning of the war, a number of specimens being made from formulas similar to, and in some cases almost identical with, those recommended by the committee.

The committee has had before it many specimens of glasses used for various purposes, of which analyses have been made by Mr. Bertram Blount, Mr. W. C. Hancock, and Mr. Otto Hehner. It has been found, however, that mixtures prepared in accordance with the analytical results were not always satisfactory; but the analyses were helpful in suggesting synthetic experiments, and during recent investigations some intricate analyses made by Mr. G. J. Alderton under the supervision of Mr. Blount have proved especially valuable. Apart from the analyses, the work has been almost entirely carried on at King's College by Prof. Herbert Jackson and Mr. T. R. Merton, and by the former at his own house. The work has involved a careful study of the chemistry of silicates, aluminates, borates, etc., in their relation to the manufacture of glasses.

Up to the present time, the research committee has reported eleven formulas for glasses for various purposes based on the results of about 400 experimental melts on a scale large enough for drawing rods and blowing small vessels. In addition, a very great number of experiments have been made in order to study the influence of the various constituents employed. No formula has been issued without submitting the specimens made to rigorous tests to prove their suitability for the purposes for which they are intended. Moreover, by varying the experimental working conditions, it can be said with reasonable confidence that the mixtures will prove equally satisfactory under the actual working conditions of a glass furnace. The question of workable temperatures has been carefully considered, and so far as it is possible to judge, the melts on a small scale indicate that even better results will be obtained on the industrial scale. This view has been justified by the samples already received from manufacturers who have tried some of the formulas.

In deciding the formulas it has been found necessary to direct special attention to the proportions of basic and acidic substances in respect of the action of glass mixtures on clay crucibles during fusion, and it has been shown by careful investigation that the formulas proposed give melts in which the influence of the ingredients of the crucibles is very slight and in some cases practically inappreciable.

The following formulas have been communicated to a number of manufacturers who have expressed their interest in the progress of the investigation and to scientific workers who are conducting experiments.

*From *Nature*.

Soft glasses, suitable for ordinary chemical laboratory ware.

	Parts		Parts
(1) Sand	67.0	Calcium carbonate	11.6
Sodium carbonate (Na_2CO_3)	34.2	Alumina (Al_2O_3)	6.5

A soft glass which does not give up alkali readily to water, works well in the blowpipe, and does not devitrify readily.

	Parts		Parts
(2) Sand	67.0	Calcium fluoride	1.6
Sodium carbonate (Na_2CO_3)	29.0	Alumina (Al_2O_3)	8.3
Calcium carbonate	9.6	Boric anhydride (B_2O_3)	2.0

A soft glass of higher quality. Does not give up alkali under severe tests. A kindly working glass before the blowpipe, and very difficult to devitrify.

A resistant glass suitable for pharmaceutical purposes, ampoules, etc.

	Parts		Parts
(3) Sand	67.0	Potassium nitrate	1.0
Alumina (Al_2O_3)	10.0	Sodium carbonate (Na_2CO_3)	17.0
Calcium carbonate	12.5	Boric anhydride (B_2O_3)	8.0
Magnesia	0.5		

This glass is intermediate in hardness between soft glass and combustion tubing, is highly resistant to chemical action, withstands changes of temperature well, and should be a very suitable glass for high-class beakers, flasks, etc.

Glasses for combustion tubing.

	Parts		Parts
(4) Sand	68.2	Sodium carbonate (Na_2CO_3)	5.5
Alumina (Al_2O_3)	6.2	Boric anhydride (B_2O_3)	5.5
Barium carbonate	8.8	Calcium fluoride	1.0
Calcium carbonate	13.0		
Potassium nitrate	4.3		

This glass resembles Jena combustion tubing very closely indeed. It has practically the same fusing point. It fuses on to Jena glass perfectly, and is indistinguishable from it before the blowpipe and in its behavior on prolonged heating below its fusing point. The presence of the small quantity of calcium fluoride facilitates the incorporation of the ingredients. The sodium carbonate can be reduced to 1.34 parts provided 7.93 parts of anhydrous borax be used in the place of boric anhydride.

	Parts		Parts
(5) Sand	68.2	Sodium carbonate (Na_2CO_3)	5.5
Alumina (Al_2O_3)	6.2	Boric anhydride (B_2O_3)	5.5
Barium carbonate	8.8		
Calcium carbonate	14.2		
Potassium nitrate	4.3		

This glass is practically of the same composition as (4). It is not so easy to make or to work, but it does not become so opaque as Jena combustion tubing on prolonged heating. As in No. (4), the proportions given for sodium carbonate and anhydrous borax can be substituted for the figures for sodium carbonate and boric anhydride.

Miners' lamp glasses.

	Parts		Parts
(6) Sand	65.0	(Sb_2O_3)	1.0
Alumina (Al_2O_3)	1.0	Potassium nitrate	3.0
Calcium carbonate	0.6	Sodium carbonate (Na_2CO_3)	14.0
Arsenious oxide (As_2O_3)	2.0	Boric anhydride (B_2O_3)	24.0
Antimony oxide			

A colorless and fusible glass withstanding rapid changes of temperature exceptionally well.

	Parts		Parts
(7) Sand	65.0	(Sb_2O_3)	1.0
Alumina (Al_2O_3)	1.0	Potassium nitrate	3.0
Calcium carbonate	0.6	Anhydrous borax ($Na_2B_4O_7$)	26.68
Arsenious oxide (As_2O_3)	2.0	Boric anhydride (B_2O_3)	5.5
Antimony oxide			

The same glass as (6), but the ingredients have been varied to avoid the use of so much boric anhydride, which is at present apparently difficult to obtain on a commercial scale.

Resistance-glass.

	Parts		Parts
(8) Sand	65.5	Sodium carbonate (Na_2CO_3)	10.2
Alumina (Al_2O_3)	2.5	Borax anhydrous ($Na_2B_4O_7$)	13.0
Magnesia (MgO)	5.0		
Zinc oxide (ZnO)	8.0		

A glass almost identical in its general behavior with Jena resistance glass; withstands changes of temperature well, but, like Jena, is not suitable for working before the blowpipe. It darkens and tends to devitrify; operations—such, for instance, as sealing side tubes into flasks—are difficult, if permanent and neat joints are required.

Formula No. 3, recommended for pharmaceutical purposes, ampoules, etc., may be substituted for the resistance glass with advantage, as the ampoule glass lends itself very well to blowpipe work, and is also especially resistant chemically.

Alternative for combustion tubing.

	Parts		Parts
(9) Sand	72.0	Potassium nitrate (KNO_3)	3.0
Alumina (Al_2O_3)	10.0	Sodium carbonate (Na_2CO_3)	11.2
Calcium carbonate	11.0	Borax anhydrous ($Na_2B_4O_7$)	7.2
Magnesia (MgO)	0.5		

This glass is capable of withstanding high temperatures and rapid changes of temperature; works well before the blowpipe, and is free from the chief defect of Jena glass—namely, the readiness with which it becomes cloudy, and finally quite opaque after prolonged use.

By slight modifications of this formula, almost any degree of hardness can be obtained.

In formulas (8) and (9) substances such as magnesia (MgO) and zinc oxide (ZnO) can be added in the form of carbonates if the actual percentages of MgO and ZnO respectively present in the carbonates are known.

Soft soda-glasses suitable for tubing and X-ray bulbs.

	Parts		Parts
(10) Sand	68.0	Potassium nitrate (KNO_3)	14.5
Alumina (Al_2O_3)	4.0	Sodium carbonate (Na_2CO_3)	26.0
Calcium carbonate ($CaCO_3$)	12.8		

	Parts		Parts
(11) Sand	68.0	Potassium carbonate (K_2CO_3)	10.0
Alumina (Al_2O_3)	4.0	Sodium carbonate (Na_2CO_3)	26.0
Calcium carbonate	12.8		

These glasses do not lose their easy-working qualities after repeated heating and blowing, and are plastic over a long range of temperature. They require a temperature of at least 1400 to 1500 deg. Cent. for complete incorporation of the ingredients in order to obtain that homogeneity which is necessary for resistance to rapid changes of temperature and ease of working before the blowpipe.

No. (10), containing potassium nitrate, is considered the better of the two, and is more easily incorporated.

The committee considers that the formula obtained and the work done on the various glasses justify it in the opinion that there is now information available for the manufacture of all the important glasses used in the laboratory and for industrial purposes, which have hitherto been mainly obtained from abroad.

An eight-wheel "American" locomotive with portions cut away to show details of construction and operation.

Railway Exhibits at the Panama-Pacific Exposition

Details and Construction of the Steam and Electric Locomotives

By H. J. Kennedy

Special Correspondent of the SCIENTIFIC AMERICAN at the Panama-Pacific Exposition

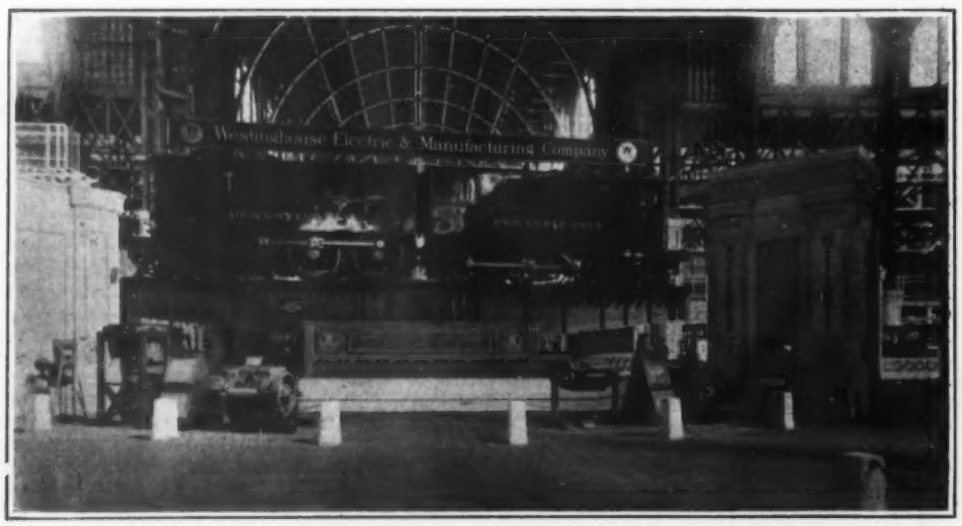
Of the hundred-and-fifty or more groups into which the exhibits at the Panama-Pacific International Exposition are divided, one of those with which practically all the exposition visitors have made close acquaintance is the railway: electric, steam, or both, according to the remoteness of their residence; and they are both there, mixed up together, steam locomotives and electric locomotives, steam railroad cars and electric cars, typifying the changing conditions in railroading; for, in the opinion of many engineers, the time is steadily approaching when electricity as a motive power will be almost as common in railroading as the air-brake. A traveler from New York to San Francisco sees this demonstrated at either end of his journey, from the electrified terminals in New York city to the web of electrified lines radiating over the cities east of San Francisco Bay; and in the Transportation Building at the exposition both are represented, from the 156-ton Pennsylvania electric locomotive slowly revolving on its elevated pedestal in the center of the building, to the 55-ton electric passenger car forming a bright vermilion object-lesson as part of the Southern Pacific Company exhibit, less than a hundred yards away.

This exposition differs from preceding large expositions in that no attempt has been made to establish a separate electrical exhibit, for the reason that electricity is so extensively applied nowadays that an electrical building would, in a sense, include most of the others. Therefore, the others have been made to include the electrical.

The greatest proportion of the area of the Transportation Building is occupied by exhibits of railway rolling stock, models, air-brakes and railway supplies of various kinds; however, there are in various other buildings, both main and State, numerous and extensive exhibits relating to railways.

Though not boasting as liberal an exhibit of rolling stock, numerically, as at Chicago or St. Louis, the railway exhibit at San Francisco is fully as significant in certain respects. The introduction into this country on a large scale of the invention of M. A. Mallet, marked by the first of the type exhibited by the Baltimore & Ohio Railroad at St. Louis in 1904, has been followed by the almost universal use of these engines for the heaviest mountain-grade traffic; and the type is represented at San Francisco by the big 2-8 8-2 freight locomotive exhibited by the Southern Pacific Company. The B. & O. locomotive was of the 0-6 6-0 wheel arrangement, and weighed 334,500 pounds, all on drivers, exclusive of tender. It was, at that time, the heaviest locomotive ever built. (Coincidentally, the B. & O. was also operating what at that time was the heaviest electric locomotive built, 160 tons in two units.) The Southern Pacific locomotive weighs 435,800 pounds, exclusive of tender; however, it is not the heaviest built. The same builders supplied to the Erie Railroad a triple-articulated locomotive with drivers under the tender, weighing altogether 853,050 pounds, of which 761,600 pounds is on twenty-four drivers, whereas the S. P. engine has 400,700 pounds on sixteen drivers.

There appears little question but that the success of the Mallet compound has retarded for several years the electrification of many mountain grades. Not far from the Southern Pacific Mallet stands one unit, weighing 80 tons (all on drivers, eight in number), of the type of electric locomotive built for the Butte, Anaconda & Pacific Railway by the General Electric Company. This is remarkable as representing the most advanced practice in freight electric locomotives using direct current, the trolley voltage being 2,400 and the motors being wound for 1,200 volts and connected permanently two in series. In practice, two locomotive units are operated together by the multiple-unit control system. This makes a locomotive of 160 tons weight on sixteen drivers.



Electric locomotives used by Pennsylvania Railroad in its Hudson River tunnels.

These two exhibits alone will enable the student of railroad locomotion to inspect the latest tendencies in freight work on heavy grades. The Butte locomotives will be exceeded, both in weight and trolley electromotive force, by the 24-wheel locomotives now being built for the Chicago, Milwaukee & St. Paul Railway, which will weigh 260 tons per double unit and will use a direct-current voltage of 3,000. The new Norfolk & Western locomotives are still heavier, weighing 270 tons on twenty-four wheels, but will be operated on the single-phase three-phase system.

Returning to general consideration of the steam locomotives: The supporting of the weight back of the drivers by trailing wheels, above which the fire-box is placed, has now become so universal as to attract no attention. Yet many of us can remember that it was at the exposition in Chicago in 1893 that this modern practice was, in the United States, brought into fashion in the locomotive "Columbia," which, however, had only a pony truck in front, replaced on succeeding models by a four-wheeled truck, giving us the "Atlantic" and "Pacific" types, now common. All the full-sized locomotives exhibited at San Francisco, with one exception, have this feature, which insures abundant space for fire-box and liberal grate area.

A noticeable feature, to eastern visitors, is the use

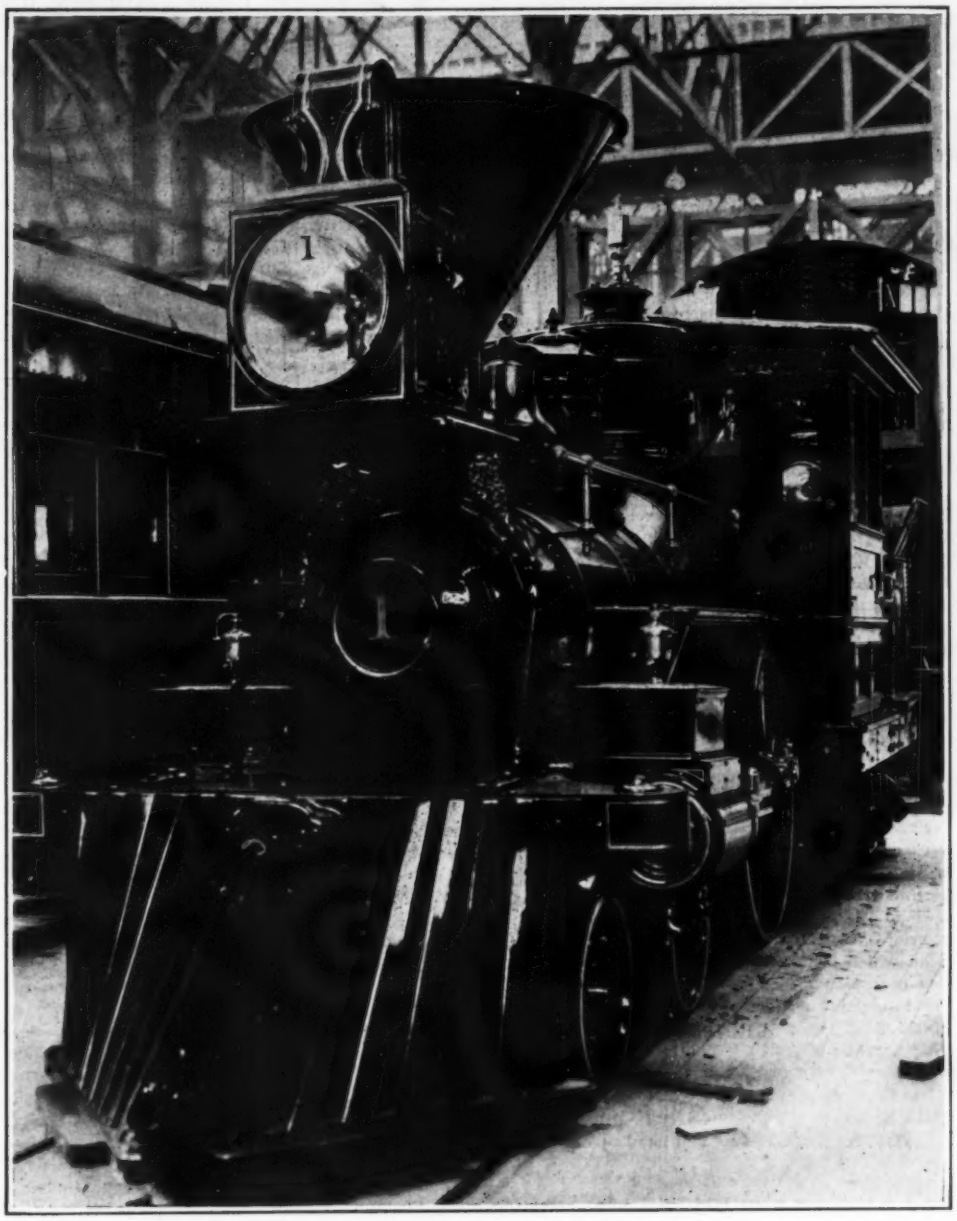
of oil fuel on most of the locomotives, this being standard practice in California and Oregon, and to a considerable extent in adjoining States. This makes possible the running of the Mallet compound with the fire-box in front, the crew being housed in a cab at that end and having nothing in front of them to obstruct their view, exactly as in an electric locomotive. Fifty-nine of this and similar types are in use on the grades in the Sierra Nevada and on the Tehachapi grades in California.

Other features, illustrating the mechanical assistance necessitated by the great size of modern locomotives, are the steam reverse gear used on several of the locomotives, and the mechanical stoker for coal, installed on one of them. Several years ago, when compound locomotives of various types were being built for different railroads, it was felt that the compound had become *the* thing. Now we have an international exposition in which there is only one compound (the Mallet), which omission may be due to the locomotive exhibit being limited and not truly representative. Instead of saving fuel by complicating the engine, an additional piece of apparatus is added to the boiler, with the result that most of the large engines exhibited are equipped with superheaters. Those who wish to study the construction of these superheaters will find models, together with full-sized superheater tubes (themselves interesting pieces of workmanship), in the exhibition. The superheaters are placed in several large flues in the upper part of the boiler, steam flowing from a header at front end of dry pipe, through superheater tubes, and returning to the front end, thence through the steam pipes to the cylinders, superheated to about 600 deg. Fahr. It is said 12,000 locomotives are equipped with them.

In this exposition, probably more than in any other, the railway exhibit is composed very largely of features designed to attract passenger travel, such as beautifully-executed models, pictures, and moving-picture lectures on scenery, stations and others things of interest to travelers, which are outside the scope of the present article. It is located principally in the northwestern quarter of the Transportation Building.

The Southern Pacific locomotive exhibit comprises:

No. 4043. Mallet articulated compound, already mentioned. Wheel arrangement, 2-8 8-2, the drivers at the fire-box end being rigid with the boiler and the other set swivelling. All wheels are flanged. Cylinders, 26 inches and 40 inches by 30 inches; 57-inch drivers; 30½-inch truck wheels; 33-inch tender wheels. Driving wheel base, 39 feet 4 inches; total engine, 56 feet 7 inches; total wheel-base of engine and tender, 90 feet 4 inches. Tender weights 189,200 pounds and carries 9,816 gallons of water and 3,610 gallons of fuel oil. Weight of engine and tender together, 625,000 pounds. Tender is of the Southern Pacific round-top type. This engine has both a superheater and a feed-water heater; working pressure, 200 pounds per square inch. The length of train it will handle is emphatically indicated by the two big two-stage Westinghouse 9½-inch air pumps on the side of the boiler.



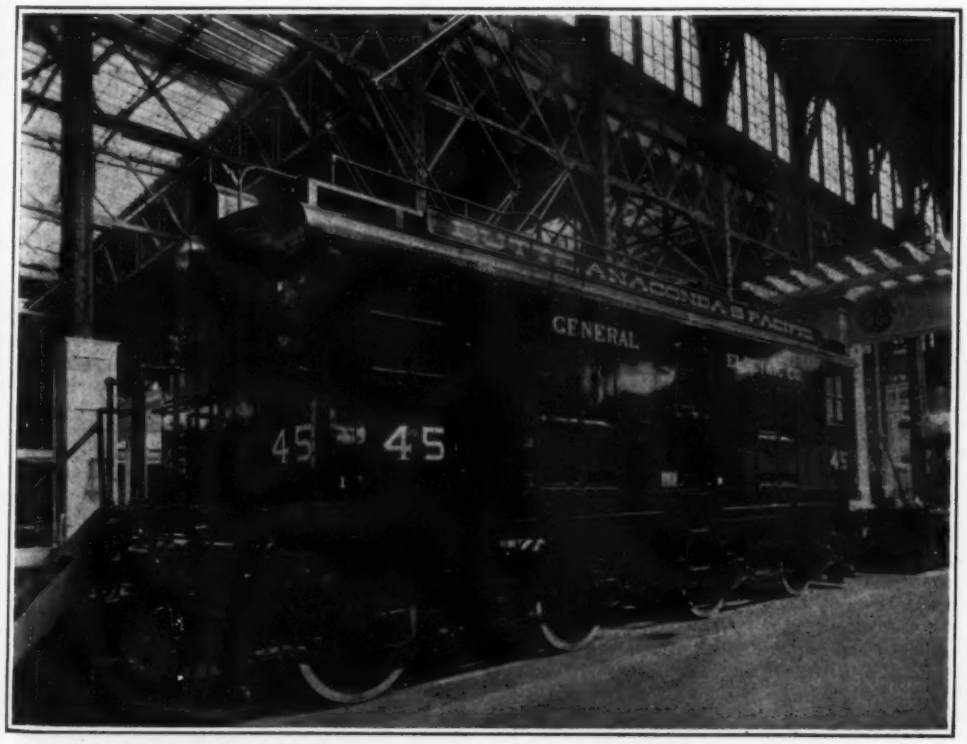
A Southern Pacific flyer of 1863, with single drive wheel.

As a contrast to the 4043, across the aisle from it is the little old "single-driver" of civil war times, the "C. P. Huntington" or Southern Pacific Company (Central Pacific, properly) No. 1, built for the first transcontinental railway by the Cooke Locomotive Works of Paterson in 1863. This is the engine which was brought around Cape Horn by ship. It is now bright and fresh-looking with vermilion wheels and maroon cab and stack and polished brass and steel. It is of the 4-2-4 wheel arrangement, with 18,500 pounds on its single driving axle; total weight, 39,000 pounds; 11-inch by 15-inch cylinders; boiler, 35½ inches, or several inches less diameter than the bore of the low-pressure cylinders of the Mallet. Working pressure, 125 pounds. Drivers are 55 inches diameter, and she carried two tons of coal in the bunker, on same frame as the engine.

The boy who is railroad-struck (probably not so prevalent in these days of motorcycles, radiotelegraphs and aeroplanes, as formerly) and a good many grown-ups will be delighted with the 1457. It forms the plainest possible demonstration of the principles of boiler and engine construction. Sections of the boiler and the dome are removed, disclosing crown-sheet and stays, tubes, water-line, throttle-valve and dry-pipe, from which the course of the steam may be traced to the steam pipes in the opened smoke-box, thence to the opened steam chest and quartered cylinder, the ports being marked with arrows, and both valve and piston slowly going through their movements, as the driving wheels are supported on rollers and are driven by an electric motor. This engine is an ordinary eight-wheel American (or 4-4-0) type.

The Atlantic type passenger engine, painted all white, which furnishes steam for the searchlight play as part of the marvelous night illumination, and which stands on rollers at the Yacht Harbor and is run at speed and with its whistle aids in the dramatic effect of the colored lights and fireworks, etc., was also furnished by the Southern Pacific. It weighs 196,000 pounds, exclusive of tender, and has cylinders 20 inches by 28 inches, and 81-inch drivers.

The only complete exhibit of modern American locomotives by builders is that by the Baldwin Locomotive Works, in the following list:



Powerful electric freight locomotive of the Butte, Anaconda & Pacific Railway.

B. L. W. No. 41,710, 2-8-2 ("Mikado") type; weight of engine, 138,550 pounds. Oil fuel, logging service; has flanges on first and last drivers and can take thirty-degree curves. Is standard gage; 44-inch drivers; working pressure, 180 pounds per square inch; 18-inch by 24-inch cylinders; it has Stephenson link instead of the now customary Walschaerts valve motion, and is equipped with a rather uncommon type of reverse gear, operated by air pressure, and located entirely inside the cab (that is, the special part of it). The back end of the reach rod is pinned to the nut of a horizontal screw which may be rotated by a small air motor above it, driving through spur-gearing. A valve in front of the engine-runner controls the air-motor; there is also a hand-crank.

S. P. Co. No. 3270, 2-8-2 type; weight, 280,960 pounds. For heavy passenger service; burns oil fuel; has flanges on all drivers; 200 pounds pressure; 26-inch by 28-inch cylinders, 63-inch drivers; noticeable features are the Ragonnet power reverse gear and Schmidt superheater. It has a Vanderbilt tender, with vestibule to meet the "blind baggage."

C., B. & Q. R. R. No. 6110, 2-10-2 type; weight, 377,100 pounds. For freight service; coal fuel; main or third pair of drivers is without flanges, and the side-rod knuckle pins have spherical joints to avoid binding on curves due to the long wheel-base (driving wheel-base is 20 feet 9 inches); 175 pounds pressure; 30-inch by 32-inch cylinders, 60-inch drivers. Ragonnet reverse, Schmidt superheater, Street mechanical stoker.

A., T. & S. F. Ry. No. 3000, 4-6-2 (Pacific) type; 288,700 pounds. For passenger service; oil fuel; 26-inch by 26-inch cylinders, 73-inch drivers; 200 pounds pressure. Special features: Baker valve motion; Ragonnet reverse gear; Schmidt superheater.

S. P., L. A. & S. L. R. R. No. 3708, 2-8-2 (Mikado) type; 282,500 pounds. For freight and mountain passenger service; oil fuel; 200 pounds working pressure. Flanges on all tires; 26-inch by 28-inch cylinders; 63-inch drivers. Ragonnet reverse; Schmidt superheater; Vanderbilt tender.

McCloud River Railroad No. 18. This exhibit is of peculiar western interest, as it includes a train from a railroad which brings out lumber from the great pine forests near Mount Shasta. The big logs on the cars are as interesting as the train itself. The locomotive is of the 2-8-2 type; 178,700 pounds engine. Logging railroad service; oil fuel; 180 pounds pressure; second and third pairs of drivers have blind tires. This railroad has 4 per cent grades and 18-degree curves; 20-inch by 28-inch cylinders, 48-inch drivers. Schmidt superheater, Walschaerts valve gear and hand reverse.

A pair of maximum traction electric motor trucks without the motors, and a model of an interurban car truck, are included in the Baldwin exhibit.

The American Locomotive Company exhibits locomotives for contractors, logging and foreign use. Two four wheel tank locomotives, one weighing 37,000 pounds, 10-inch by 16-inch cylinders, 36-inch gage, the other for standard gage, weighing 89,000 pounds and having 16-inch by 24-inch cylinders, are shown.

The brightly polished stack top and other parts, and the Chinese lettering on the tender, mark the representative of foreign trade, K.-S. Ry. No. 80, 2-8-2 type, standard gage, 138,500 pounds on drivers, 186,000 pounds total, 296,400 pounds with tender. In addition to the air-brakes, it has a screw hand-brake; also a rather unusual fire-door opener. For freight service; coal fuel; 180 pounds pressure; 20-inch by 28-inch cylinders, 50-inch drivers, all flanged except the main drivers. The boiler is equipped with superheater.

A. L. Co. No. 54,257, 2-8-2 type, for logging service, 144,500 pounds on drivers, 190,000 pounds total engine. Coal fuel; 180 pounds pressure; 20-inch by 28-inch cylinders, 48-inch drivers; Walschaerts valve gear, hand reverse.

There is not space here to enumerate the various locomotive models, etc., to be found at various parts of the exposition; many of them are, however, of much interest.

ELECTRIC LOCOMOTIVES.

Important developments have been occurring in the electric traction field in the last few years. Among them is the rapidly-increasing use of the high-voltage direct-current trolley, and the maturing of the single-phase system into a single-phase current collection with three-phase motors fed through a "phase-splitter" carried on the locomotive. But, despite the number of alternating-current locomotives in use, none are exhibited at San Francisco; however, a separate single-phase motor from the new Philadelphia-Paoli electrification is exhibited. The side-rod drive is represented by the Pennsylvania locomotive; with the exception of this and the Norfolk & Western Railway, it has received scant recognition in the United States, though much used in Europe.

The two most interesting electric locomotives exhibited are the P. R. R. locomotive No. 38, mounted on a slowly-revolving turntable with swingbridge driving gear (better consider it a swingbridge, as a double-ended locomotive requires no turntable) in the center of the building, and the B., A. & P. R. R. locomotive already mentioned.

The Pennsylvania locomotive, on account of its use in the New York terminal, is well known by this time but a few leading dimensions will be repeated here for reference: Weight of complete locomotive, two units 156 tons; weight on eight drivers, 100 tons. One 2,0 horse-power motor on each unit; total horse-power p locomotive, 4,000; 600 volts direct current, third r and trolley; 72-inch drivers.

The No. 45 is only one half of a complete locomoti as used on the B., A. & P. This unit is formed of t four-wheel trucks articulated together and carrying steel-plate cab. All wheels are drivers (56 inches dia eter) and the unit has four 320 horse-power motor total horse-power of unit 1,280, or 2,560 horse-power a double-unit locomotive, compared with 3,430 in th new C., M. & St. P. locomotives (eight motors), an 5,000 horse-power in the N. & W. Ry. locomotives (eig motors). Twenty-one of these Butte locomotives are i service hauling heavy trains loaded with ore at 15 mile an hour; some of them are geared for higher speed an haul passenger trains at from 45 to 50 miles per hou

Each unit is double-ended, being equipped with co trollers in a compartment at each end, with connecte giving utmost flexibility of arrangement for multiple unit locomotive operation. Between the motorman compartments there is a room filled, except for a na row passage on each side, with apparatus; contactor near the floor, resistance above them, a four-cylinde two-stage air compressor at one end, run by a 600-vo motor, a dynamotor furnishing 600-volt current for ai compressor, control circuit, etc., at the other end, be side which are main switch, fuses, dynamotor startin switch, etc., and a Sturtevant blast fan which takes ai out of the cab and forces it through the motors, en abling them to be worked at a heavy load without over heating, in spite of being cased up. Openings in side of cab supply air to the interior. The end compart ments can be closed off by doors to prevent chilling i cold weather by the air in the middle room, as Montan winters are very cold. The unit is equipped with tw pantagraph trolleys with contact rollers, raised or low ered from motorman's cab, by pneumatic cylinder co trol. In the picture, one is shown raised, the othe down.

The Mallet steam locomotive has contributed to it electrical rival a valuable detail which is being gen erally adopted on the heaviest electric locomotives, viz, the articulation, or hinge, by which one truck is cou pled to another independently of the framework above which, being thus relieved of pulling or pushing stresses may be reduced in weight, allowing more weight, if de sired, to be put into boiler or motors, as the case may be, with corresponding increase of horse-power capacity.

Recent Progress in Astrophysics—II*

Many Important Discoveries That Add to Our Knowledge of the Heavenly Bodies

By Prof. C. G. Abbot

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2063, Page 46, July 17, 1915

MEASUREMENTS OF SOLAR RADIATION.

In the Smithsonian Report for 1912 the writer gave an illustrated account of the investigations of solar radiation by the Astrophysical Observatory of the Smithsonian Institution. In July, 1913, the results of this long investigation were published with details in volume 3 of the Annals of the Astrophysical Observatory. The most important conclusions are as follows:

1. The mean value of the solar constant of radiation for the epoch 1905–1912 is 1.932 calories per square centimeter per minute.

2. An increase of 0.07 calory per square centimeter per minute in the "solar constant" accompanies an increase of 100 sun-spot numbers.

3. An irregular variation frequently ranging over 0.07 calory per square centimeter per minute within an interval of 10 days is established by numerous early simultaneous measurements at Mount Wilson, Cal., and Bassour, Algeria.

4. Indications of two wholly independent kinds incline us to think that these variations of solar radiation are caused within the sun, and not by interposing meteoric or other matter.

STELLAR PROBLEMS.

The Distances of the Stars.

The actual distances of several hundred of the stars can be said to be known within moderate limits of accuracy. Various methods are used for determining the distances of the stars, but they generally depend upon the fact that the earth, by reason of its revolution about the sun, occupies places separated by 186,000,000 miles at intervals 6 months apart. This corresponds to the surveyor's base line, and allows us to triangulate for the distances of the stars. Another method of estimating the stellar distances may be based upon the fact that the solar system is approaching the constellation Hercules at the rate of about 20 kilometers (12 miles) per second, so that the position occupied by the earth in space to-day is different from that which will be occupied to-morrow by reason of the motion of the solar system, but this method involves assumptions in regard to the motions peculiar to the stars observed.

It is customary to express the distances of the stars in light-years, for the distances of the stars, if given in kilometers or miles, or even in terms of the radius of the earth's orbit, are so enormous as to require many figures. Light, however, traveling at the rate of 186,000 miles per second, in the course of a year travels about 6,000,000,000,000 miles. In terms of this unit the nearest star is at a distance of four and a half light-years. The stellar distances are considered up to such enormous quantities as a thousand or more light-years. It is also customary to speak of the parallaxes of stars. By this is meant the angle which the radius of the earth's orbit would subtend if viewed most favorably from the star in question. The parallaxes of the stars range from about one second of arc (1 second) downward. The following table shows the relation between miles, light-years, and parallaxes of stars:

Star.	α Centauri.	Procyon.	Altair.	Castor.	Arcturus.	Antares.
	Seconds.	Seconds.	Seconds.	Seconds.	Seconds.	Seconds.
Parallax	0.75	0.33	0.23	0.10	0.066	0.02
Light-years	4.5	10.0	14.5	33.3	50.0	166.7
Miles*	*27,000,000	*60,000,000	*87,000,000	*200,000,000	*300,000,000	*1,000,000,000

* 000,000 omitted.

The first successful measurements on stellar parallaxes were made by Struve at Dorpat on the star Vega in the years 1835 to 1838, and by Bessel on the star 61 Cygni, 1837 to 1840. Bessel's result was 0.35 second. This value is in close accord with recent measurements. It was a great feat to measure such a small angle as this. In modern practice the efforts to measure parallaxes absolutely have practically been discontinued, for it is found that the very faint stars are so immensely distant from us as hardly to be displaced at all in their apparent positions by the motion of the earth in its orbit. Hence, for stars which are near enough to be observed for parallax it suffices to compare their positions with respect to the faint stars in their neighborhoods at two epochs separated from one another by six months.

Many of the parallax determinations of great weight have been made by use of the heliometer, which is a telescope with its objective lens cut in half, with the two parts movable with respect to one another by a fine screw. With this instrument the images of two celestial objects, one formed by one half of the lens and the other

* Annual report of the Smithsonian Institute, 1913.

by the other may be brought into coincidence by shifting the two parts of the lens with respect to one another, and the scale of the instrument gives thereby an indication of the angular distance between the two objects in the heavens. Thus the relative positions of the stars may be observed for parallax purposes.

Stellar parallax measurements by means of the heliometer have been the main work of the Astronomical Observatory of Yale University. A volume of the Transactions of the Observatory has been issued recently containing the results. The parallaxes of 195 stars have been ascertained with an average probable error of 0.015 second. The stars investigated at Yale naturally do not include stars visible only in the southern hemisphere. The parallaxes of some of the southern stars have been observed with the heliometer from the Observatory of the Cape of Good Hope. Of the parallaxes determined at Yale the largest pertaining to a bright star is 0.33 second for the star Procyon, whose magnitude is 0.6, and which has a proper motion in the sky of 1.23 seconds per century.[1] According to the little table just given it will be seen that this corresponds to a distance of 10 light-years. The largest parallax found for any star by the observations at Yale was 0.39 seconds for the faint star known as Lalande 21185. This star is invisible to the eye, being of magnitude 7.3 and has a proper motion of 4.77 seconds per century.

Another method of parallax investigation which has been developed in recent years to a high state of perfection is that by photography. If a photograph of a celestial region containing the star whose parallax is to be determined is made in the earlier part of the night at one epoch, and again in the latter part of the night at an epoch six months later, the position of the parallax star will in general be found to be changed with respect to the mean position of all the fainter stars in its neighborhood. After clearing the apparent motions for the known proper motions of the stars in question, a residual effect will be left, due to the fact that the parallax star is in general nearer than the fainter stars in the background. In a method proposed by Kapteyn the photography was done in the following manner: A plate was exposed at a certain epoch, then kept without developing for 6 months, exposed again in a slightly different position, and then kept still another 6 months, and finally exposed a third time before developing. Thus three series of images of all the stars would be found upon the plate, of which two would be taken with the earth in one part of its orbit and the other with the earth at the opposite part. Recently Prof. Schlesinger, formerly of the Yerkes Observatory, now director of the Allegheny Observatory, has used the photographic method with the great Yerkes refractor, and has obtained parallaxes for about 25 stars of a very high order of accuracy. Prof. H. N. Russell, of Princeton, also has obtained excellent results by this method for 52 stars observed by himself and Hinks at Cambridge, England. These observers did not leave the plates undeveloped for a year or 18 months, according to the method proposed by Kapteyn, but preferred to take separate plates at the different epochs. This parallax work by photography is becoming extremely well thought of by astronomers, and is engaging more and more the efforts of those who have large refracting telescopes available for this purpose.

It is found, as would be expected, that in general the brightest stars are nearer the earth, and the stars whose proper motions are largest are also nearer the earth. Prof. Kapteyn published, in 1902, a formula connecting the quantities parallax, stellar magnitude, and proper motion. This is found to agree pretty well with more recent work. Prof. Lewis Boss, in his interesting discussion of the great Preliminary General Catalogue of positions and proper motions of stars, recently published by the Carnegie Institution, has also derived a formula connecting the proper motion and the parallax for stars of the 5.3 magnitude.

The positions of the stars in the heavens change slightly from year to year, owing to two causes: First, the motion of the solar system as a whole in the direction toward the constellation Hercules; second, the individual motions peculiar to stars themselves. The first-mentioned component of proper motion increases directly as the stellar distance decreases. Stellar parallax observers, being overwhelmed by the enormous number of the stars, were obliged to choose from them a small list for observation. It was natural to select stars of large proper motion for such a purpose, since these would probably represent the class nearest to the earth. Hence if we take, for instance, from the list of stars whose parallax has been determined a group whose mean parallax is 0.1 second, the mean of their proper motions exceeds the mean proper motion, which would be found for all the stars whose parallax is 0.1 second, if all those stars had been investigated. Hence it must occur that, as the distances of more and more of the stars become known, our estimated value for the mean distance corresponding to stars of a given brightness or a given proper motion must diminish.

[1] The stars have long been arranged with respect to their brightness, by "magnitudes." A number of the brightest stars in the heavens are regarded as of the first magnitude. The Polar Star is of the second magnitude, and the brightness of the faintest of the six readily visible stars in the constellation Pleiades is 4.4 magnitudes. An increase of five magnitudes corresponds to a decrease of a hundredfold in the brightness of the stars. It was found when the measured distances of the stars were arranged in the order of the magnitudes of the stars observed that the brighter stars were on the whole nearer to us than the fainter ones.

The "proper motion" of a star is ordinarily given as the angle through which the star moves in a century in the heavens, after allowances are made for all effects of nutation, precession, aberration, etc., but not for the motion of the solar system toward the constellation Hercules. Proper motion, therefore, includes the star's real motion in space with reference to the whole system of stars and, in addition, the star's apparent motion, really due to the motion of the solar system toward the constellation Hercules. Proper motions tend, of course, to diminish the greater the distances of the stars considered.

MOTIONS OF THE STARS.

Within the last few years great pieces of statistical investigation in relation to the stars have been published which are of the highest value for the progress of our knowledge of the universe. Americans should be particularly proud of several of these investigations.

The first is by the Harvard College Observatory, under the direction of Prof. E. C. Pickering. Volume 50 of its annals, containing the Revised Harvard Photometry, gives a catalogue of the positions, photometric magnitudes, and spectra of 9,110 stars, mainly of the 6.5 magnitude and brighter, covering both the northern and southern hemisphere. A still more extensive work of a similar kind, to be called the Revised Draper Catalogue, which will include data for probably 200,000 stars, is now in course of preparation at the Harvard College Observatory and may be expected to be finished within a short time, thanks to Prof. Pickering's great care in the arrangement of the work.

The second great work to which I refer is entitled "Preliminary General Catalogue of 6,188 stars for the epoch 1900. Prepared at the Dudley Observatory, Albany, N. Y., by Lewis Boss and published by the Department of Meridian Astrometry of the Carnegie Institution of Washington, 1910." Prof. Boss says: "The general catalogue of 6,188 stars herein contained is the result of an attempt to deduce for these stars the most exact positions and motions that are readily attainable from the means at command." In compiling it he has compared about 80 star catalogues, from the catalogue of Bradley, dated 1755, to modern catalogues of the period 1900. From these he has deduced the most probable positions in right ascension and declination of the stars, and the proper motions of the stars as indicated by the observations of them at long separated epochs. The result obtained with regard to proper motion have led him to a most interesting series of papers, some conclusions of which will be referred to in what follows:

The third great piece of work to which I have referred is not yet published *in extenso* but has been published in part. It exists in manuscript, and the principal conclusions to be immediately derived from it have already been published in a series of interesting papers by Prof. W. W. Campbell, director of the Lick Observatory.

It is now 16 years since Director Campbell described the Mills spectrograph of the Lick Observatory. This fine instrument, remodeled in 1902, has been unremittingly used by him until the present time. A companion Mills spectrograph was installed under Director Campbell's direction in Chile in the year 1903, and this also has been diligently employed by successive observers sent down from the Lick Observatory.

It was Director Campbell's intention in this long campaign to observe the spectra of all stars brighter than the fifth magnitude, in both the northern and southern hemispheres, in a manner adapted to determine accurately the motion of each of these stars in the line of sight: that is to say, in a direction toward or from the earth. This motion is also termed radial velocity. The time of exposure necessary for photographing a single spectrum ranges from a few minutes up to several hours, according to the brightness of the star and the quality of the atmospheric conditions. It is necessary in such a campaign as that which the Lick Observatory has been making to observe each of the stars several times in order to confirm the velocity found or to detect the presence of variability of velocity, such as often leads to the most interesting results. The Lick Observatories in California and Chile have observed between 1,000 and 2,000 stars for radial velocity, and these, with a considerable number of others observed by other observatories, made up a list exceeding 1,700 in number, which was discussed by Director Campbell in a series of papers in the year 1911.

About one-fourth of the stars observed were found to be spectroscopic binaries. That is to say, although they appeared to be single points of light to the telescope, yet certain peculiarities in the displacements of their spectrum lines from time to time indicated that each of the apparent points of light embraced a system of celestial objects comparable in some respects with the solar system. This similarity, however, does not extend to details, for the objects included in a spectroscopic binary, or multiple star, are each usually hot enough to give light by itself, and in general are objects of more approximately equal size than the sun and the planets. The motions of a considerable number of these spectroscopic binaries have been investigated by mathematicians, and the orbits of the motions have been determined, but there still remains a large number of them for which this information is not yet available. These latter objects were rejected from Prof. Campbell's general discussion of the stellar motions on account of the indefiniteness which must attend their motions for a time. There are besides a considerable number of stars whose spectra are so vague and difficult to measure that the results from them are uncertain. Accordingly, there remained available for his investigation only about 1,200 objects.

The first investigation relates to the motion of the solar system in space. As in a forest walk the trees in front seem to separate as we approach and those behind to come together as we recede, so the stars to the telescopic observer would appear to crowd toward the point of the sky from which we are receding and to separate from that point of the sky toward which we are approaching, if the sun with the planets is in motion in the heavens with respect to the positions of the stars. Such tendencies were noted by Sir William Herschel in 1783, from a consideration of the proper motions of 13 stars, all then available. He found that the solar system was traveling approximately toward the star λ Hercules, in right ascension 262 degrees, declination, +26 degrees.

The information found by the spectroscope relates to motion at right angles to that which is observed by the telescope, so that while the telescopic observer would find the stars precisely in the solar apex to have no component of motion caused by their relations to the solar system, the spectroscopic observer would find these stars to be approaching the earth with the maximum velocity, while those at the opposite point would be receding from the earth with the same velocity. The telescopic observer, looking at right angles to the line of motion of the solar system, would see the stars at the maximum velocity, whereas the spectroscopic observer, looking in the same direction, would find no radial velocity at all caused by the solar motion.

Director Campbell's general solution for the solar motion derived from all the stars investigated, 1,193 in number, gave the following values: Apex at right ascension, 268.5 degrees, declination +25.1 degrees, and velocity 19.5 kilometers per second.

In Prof. Lewis Boss's discussion of the proper motions of 6,188 stars, he also has derived the position of the apex toward which the solar system is approaching. He finds it in right ascension 270.52 degrees, declination +34.28 degrees, and he finds that for stars situated at 90 degrees from the apex, which of course, will show the greatest apparent velocity of recession from the apex, the mean rate of apparent motion is 3.85 seconds per year. This is called the mean solar parallactic motion for the star group. Now, of course, the parallactic motions of the stars depend upon their distances from the earth, and naturally will be less for the fainter stars than for the brighter ones, since the fainter ones are situated at the greatest distances.

The mean magnitude of all the stars investigated by Boss was 5.7, but he selects 559 stars having large proper motions whose average magnitude was 5.3 and for which the mean solar parallactic motion was 21.58 seconds. Prof. Boss then goes on to compare the magnitude and parallaxes of 130 stars whose parallaxes had been measured, and thereby obtains a formula connecting the parallax and proper motion for stars of the magnitude 5.3. He thus has a measure of the distance of the stars of large proper motion which he is considering, and from this he finds that the velocity of the solar system, in its motion toward the constellation Hercules, is 24.5 kilometers (15 miles) per second. Readers will note that this value is derived quite independently from that of Prof. Campbell, and that it is about 25 per cent larger than his. But from the considerations above mentioned (under the caption "Distances of the stars") probably a reduction of the estimated distances corresponding to given proper motions will be brought about as more determinations of stellar distances become available. Thus Prof. Boss's estimate will be brought down toward that of Prof. Campbell.

(*To be concluded.*)

Duff or Dust in Coal

FINELY divided material above a certain per cent is more detrimental to the effective combustion of coal than is ordinarily realized. When the percentage of material passing through a screen having ¼-inch, round perforations exceeds a certain amount, the difficulties of operations are greatly increased due to the decreased amount of draft, the unevenness of the fire, the honeycombing of flues, the slagging of arches, and other objectionable conditions. A guaranteed maximum of duff should therefore be established. An excess over such maximum percentage should subject the coal to penalty or rejection at the option of the consumer.

NEW BOOKS, ETC.

OUR NATIONAL DEFENSE. The Patriotism of Peace. By George H. Maxwell. Washington; Rural Settlements Association, 1915. 8 vo.; 400 pp.

Our authors opposes militarism as innately aggressive, readily corrupted in the interests of capital, wastefully expensive and generally inadequate. He is, however, keenly alive to the necessity of preparedness, and seeks to attain this condition by several means, but chiefly by the "Homecroft Reserve System." What Mr. Maxwell proposes has for the most part already been successfully tried in Switzerland, Austria and New Zealand. He admits that foreign systems cannot be triumphantly transplanted *in toto* to our shores. Briefly, his suggestion is that the people provide a reserve of enlisted men under civil control, doing the work of peace in time of peace, ready for the work of war in time of war, while the War Department trains officers for the reserve. The organization of a National Construction Reserve and of a Homecroft Reserve might be carried out by forming a Board of River Regulation and by working out through that Board the necessary plans for co-ordinating other departments with the War Department. While some of the author's opinions are questionable—particularly where he denies to our army constructive imagination, initiative, and scientific genius, his main proposals are worthy of careful study, and contain features that must sooner or later be incorporated into our national life.

NEWSPAPERS AND LIBEL. A Concise Summary of the Law of Libel as it Affects the Press. By William G. Henderson of the New York Bar, Rutherford, N. J.; Chemical Bank Note Company, 1915.

W. G. Henderson's "Newspapers and Libel" is an attractive little volume which summarizes in a succinct and interesting form the law of libel with its relation to the press. There is no hard and fast rule by which the truth or accuracy of the facts appearing in a newspaper may be measured. To be sure, the main object of the press is to publish only that which is true, but the occasions are many when it is a difficult, if not almost impossible, matter to distinguish the truthful from the untruthful. Quite severe, then, is the legal ruling which declares that a newspaper prints an untruth at its peril. The law, Mr. Henderson states, presumes that such an act is committed with intent and malice, although in reality no such motives may have actuated its publication. We do not know whether he has reference here to the American or English law, but certainly it is not according to the English law, and the American law is, in a large measure, based on it. Truly, as Mr. Henderson says, it takes sound judgment and great discretion to record the news of the day and keep it free from libelous and defamatory articles.

The law allows but one form of defense to the press to defeat an action for libel, and that is justification or truth in the information published, and that the charges when put to the proof are found to be true by a preponderance of evidence.

In the tendency of the public to believe all that it sees in print lies a newspaper's power to create and mold public opinion. The two conflicting situations with which a newspaper has to contend, then, are on the one hand to keep strictly within the law, and on the other to fulfill its obligations to the public by printing the news of the day at the risk of publishing a libel.

Libel as it pertains to newspapers is divided into two classes—excusable and inexcusable or gross libel, in the determination of which the reporter plays no unimportant part.

RESUSCITATION. By Charles A. Lauffer, A.M., M.D., Medical Director, Westinghouse Electric and Manufacturing Company, New York. John Wiley & Sons, Inc., 1915. Price 50 cents.

In a substantially bound volume small enough not to encounter the pocket, Dr. Lauffer upholds manual methods of restoring respiration and strongly deplores leaving a man unaided while a messenger is sent four miles for a pulmotor. In fact, Dr. Lauffer leaves us in no doubt as to his opinion, for he declares that up to the present time the manual method is, all things considered, superior to the mechanical, and that of the six recognized manual methods the Prone Pressure (or Schaefer) is the standard. It is this system that the little volume sets out in detail, for adoption in cases of electric shock, traumatic shock, drowning, or asphyxiation from any cause. Anatomical details and general directions are so plainly given as to make the work perfectly adapted for self-instruction.

THE HUMAN GERMAN. By Edward Edgeworth. New York: E. P. Dutton & Co., 8vo.; 290 pp. Price, $3 net.

"The Human German" is a keen satire on that German love of order and minute detail which permeates the Fatherland and molds its national and individual character. The House Statutes of Berlin forbid you to enter your bath between 11 P. M. and 7 A. M., to play or sing unless all windows are closed, and to do family washing in the home. Your very balcony flowers must be watered in accordance with police regulations. German bureaucracy is a broad target. There is Herr Dransfeld, whose official designation is *Staatsschuldigungstilgungskassegeldsäkler*. There are even broader targets than this, but as the reviewer's task is rather to make two bodies of doctrine occupy the same space at the same time, we must pass on, merely noticing that Herr Dransfeld's duty is to pay off the National Debt. Unmerciful as is the light projected by Mr. Edgeworth upon German idiosyncrasies *in puris naturalibus*, it is but fair to say that he evinces a real appreciation of the national qualities, with no gleam of malice to spoil his humor. Such captions as "The Human Maidservant," "The Human Inside," and "The Human Kaiser," each presage a laugh for some leisure hour.

ROBERT'S RULES OF ORDER REVISED. For Deliberative Assemblies. By General Henry M. Robert, U. S. Army. New York: Scott, Foresman Co., 1915. 16mo.; 323 pp. Price, $1.00.

General Robert's "Rules of Order" was first published thirty-nine years ago, and has since helped a half million readers to an understanding of the principles of parliamentary law. The present revision carries nearly twice the subject-matter of the last edition, and incorporates the latest practice in deliberative assemblies. Part I is a compendium of parliamentary law, based upon the rules and practices of Congress. Part II explains methods by which the business of societies, conventions and other bodies may best be organized and conducted.

PRODUCTIVE ORCHARDING. Modern Methods of Growing and Marketing Fruit. By Fred C. Sears, M.S., Professor of Pomology Massachusetts Agricultural College. Philadelphia: J. B. Lippincott Company, 1915. 8vo.; 315 pp.; 157 illustrations. Price, $1.50 net.

PRODUCTIVE POULTRY HUSBANDRY. A Complete Text Dealing with the Principles and Practices Involved in the Management of Poultry. By Harry R. Lewis, B.S. Philadelphia: J. B. Lippincott Company, 1914. 8vo.; 536 pp.; 329 illustrations. Price, $2 net.

These are two volumes of the "Farm Manuals" series—a series to be commended in that it makes its volumes large enough to do justice to their subjects without resorting to unnatural compression or abbreviation, as so many "handbooks" do. Orcharding, properly conducted, may be a healthful and profitable occupation, and "Productive Orcharding" discusses the right man, the right soils, and the right methods. Implements, insect pests and diseases, sprays, grafting, thinning, picking equipment, packing and marketing, together with the hundred and one other points that must be mastered before success is spelled, are taken up singly, and not left until the student is in possession of sufficient knowledge to meet the emergency. "Productive Poultry Husbandry" just as thoroughly sets forth the lore of the chicken farm. From the construction of the poultry houses to marketing the eggs and exhibiting both poultry and products, nothing is omitted. The illustrations are essentially practical, and give the clearest ideas of such things as the methods of caponizing, of sticking and dry picking, and of the numerous other means and methods that make all the difference between business remuneratively conducted and business at a loss.

DOUBLE ENTRY BOOKKEEPING UP TO DATE. By Augustus Armstrong. New York: Armstrong & Co., 1915. 8 vo.; 64 pp. Price, $1.

Here are set forth the elemetary principles of entry system, and a new form is offered for combining the cash, sales and purchase books. There is also a compilation of information on subjects such as commercial arithmetic, customs business, stocks and bonds, etc.

FRANCE IN DANGER. Or French Nationality Menaced by Pan-German Aggression. By Paul Vergnet. Translated by Beatrice Barstow. New York: E. P. Dutton & Co., 1915. 8 vo.; 167 pp. Price, $1 net.

"I am exaggerating nothing. My part is merely to produce documents, to set forth and give their true value to facts and theories which are too little known in France." This declaration, appearing in substance throughout M. Vergnet's work, must of course be accepted with some caution, since "giving full value to facts" is equivalent to a personal interpretation. The Pan-German league, what it does and what it aims to do, is circumstantially set forth. The work quotes extensively from German sources to prove the irritations and burdens France has had to bear; in short, the author seeks to show "what it really means to have Germany for a neighbor." The work first appeared in Paris in October, 1913, hence its forecast and its warnings now clothe themselves in the aspect of true prophecy.

POWER, HEATING AND VENTILATION. Part III. Combined Power and Heating Plants. A Treatise for Designing and Constructing Engineers. Architects and Students. By Charles L. Hubbard, B.S., M.E. New York: McGraw-Hill Book Company, Inc., 1915. 8vo.; 408 pp.; illustrated. Price, $3 net.

We have already taken occasion to notice the first two volumes of this series. The third and final volume deals particularly with power and heating equipment for large buildings of various descriptions. The modern hotel or office building calls for a complex installation offering various services from elevators and vacuum cleaning to pumping and fire protection. All problems are broadly treated with special reference to the steam requirements, and it is assumed that the reader is already familiar with the ordinary details of heating and ventilating design. After a study of this work, he should be qualified to decide upon the system best suited to a given set of conditions, to determine whether or not any advantage is offered by generation of power upon the premises, and to answer intelligently questions of type and arrangement.

INSECTS AND MAN. An Account of the More Important harmful and Beneficial Insects, Their Habits and Life-Histories. Being and Introduction to Economic Entomology for Students and General Readers. By C. A. Ealand, M.A. New York: The Century Company, 1915. 8 vo.; 343 pp.; illustrated. Price, $3.50 net; postage, 20 cents.

Four insect-species alone cost the United States $92,000,000 every year. Were not the insect world fortunately divided against itself, in less than a decade the human race would be extinct. Insects infect and destroy plant life and multiply some of the most deadly diseases that man is heir to. Only by widely disseminated knowledge, scientifically applied, may we control their dangerous activities; and it is the chief aim of this work to supply that knowledge. By anecdote and photograph, by statistics and graphic representation, the author clinches his lessons and enhances the popular appeal of his information. In discussing insect perniciousness, the benefits conferred upon humanity by many species are not lost sight of. The bee is of course a conspicious illustration of this side of the question. The high importance of Prof. Ealand's facts is equaled only by the skill with which he presents them. The result is a volume heartily to be commended to every reader.

ALONE IN THE SLEEPING-SICKNESS COUNTRY. By Felix Oswald, D.Sc., F.G.S., F.R.G.S. London: Kegan Paul, Trench, Trübner & Co. Ltd., 1915. 8vo.; 231 pp.; 70 illustrations and map. Price, $3 net.

Whatever Dr. Oswald has to say is always not only worth saying, but well said. When, therefore, he turns from Miocene deposits to the habits and characteristics of the Kavirondo negroes, we are justified in expecting a literary treat. For these negroes of the Victoria Nyanza basin, interesting as they are in their own individual and tribal peculiarities, are still more interesting from a pathological point of view. They live in a region where the dread "sleeping sickness" holds sway; where the crocodiles are apt to charge you with the rush of an infuriated rhinoceros; and all this but three weeks away from London. Dr. Oswald calls our attention to the fact that the seventh chapter of Isaiah seems to contain a reference to the tsetse fly, the carrier of the sleeping sickness. We are gratified to find at least one chapter devoted to the hunt for the Dinotherium, although the record of the author's geological activities is aside from the purpose of the volume. The special map, from his prismatic compass traverses, and sketches by the way, shows the country between the Victoria Nyanza and the Kisii Highlands, and makes it possible to follow his route with complete understanding. His photographs are remarkable clear, each subject being selected with unerring judgment as to its elements of value and appeal.

GEPANZERTE RITTER. Von Dr. Kurt Floericke. Stuttgart: Kosmos Gesellschaft der Naturfreunde. Franckh'sche Verlagshandlung.

Dr. Floericke, under the picturesque title "Knights in Armor," has given us a popular account of land and sea animals with protective shells. His examples, as might be expected, are taken from crustaceans and insects chiefly.

VOCATIONAL MATHEMATICS. By William H. Dooley, Principal Technical High School, Fall River, Mass. New York: D. C. Heath & Co., 1915. 12mo.; 341 pp.; illustrated. Price, $1 net.

The academic method in mathematics does not always meet vocational needs; it is to bridge the gap that "Vocational Mathematics" has been written. It is intended to supplement the regular course, and to apply the principles of mathematics to the daily needs of manufacturing life. Its instruction specifically deals with carpentering and building, with sheet metal work, with bolts, screws and rivets, with shafts, pulleys and gears, with plumbing and hydraulics, with steam engineering, and with electrical work. There is a section on mathematics for machinists, and another on textile calculations. A lengthy appendix deals with tables, graphs, and formulas. The need for a text of this nature has long been evident, and a work that can procure results in the practical handling of everyday problems has a useful future before it.

THE SPELL OF FLANDERS. By Edward Neville Vose. Boston: The Page Company, 1915. 8vo.; 516 pp.; illustrated. Price, $2.50 net.

THE SPELL OF SOUTHERN SHORES. Or, From Sea to Sea in Italy. By Caroline Atwater Mason. Boston: The Page Company, 1915. 8vo.; 428 pp.; illustrated. Price, $2.50 net.

In "The Spell of Flanders," history, legend, and modern life are harmoniously mingled, their colors blending to form a vivid picture of a region now battle-torn and impoverished. Flemish Belgium, with its Gothic churches, its ornate guild houses, its mediaeval dwellings and its wealth of art and industry, defines itself before us under the strokes of Mr. Vose's facile pen. His narration is always easy, even gossipy, in places, and the abundant illustrations from original photographs enhances the appeal of the volume. In "The Spell of Southern Shores" Caroline Atwater Mason contributes her third volume to the Spell Series, and maintains the charm of her earlier work. We explore the maritime provinces of western Italy and girdle Sicily. We encounter the Mediterranean in one of its rare fits of ferocity. We visit the cloister, the palace and the villa, absorbing historical facts by the way. Where history and scenery are touched upon the narrative may be accepted as authentic; but enough fictional characterization is introduced to lighten the reading and add humor to the lines.

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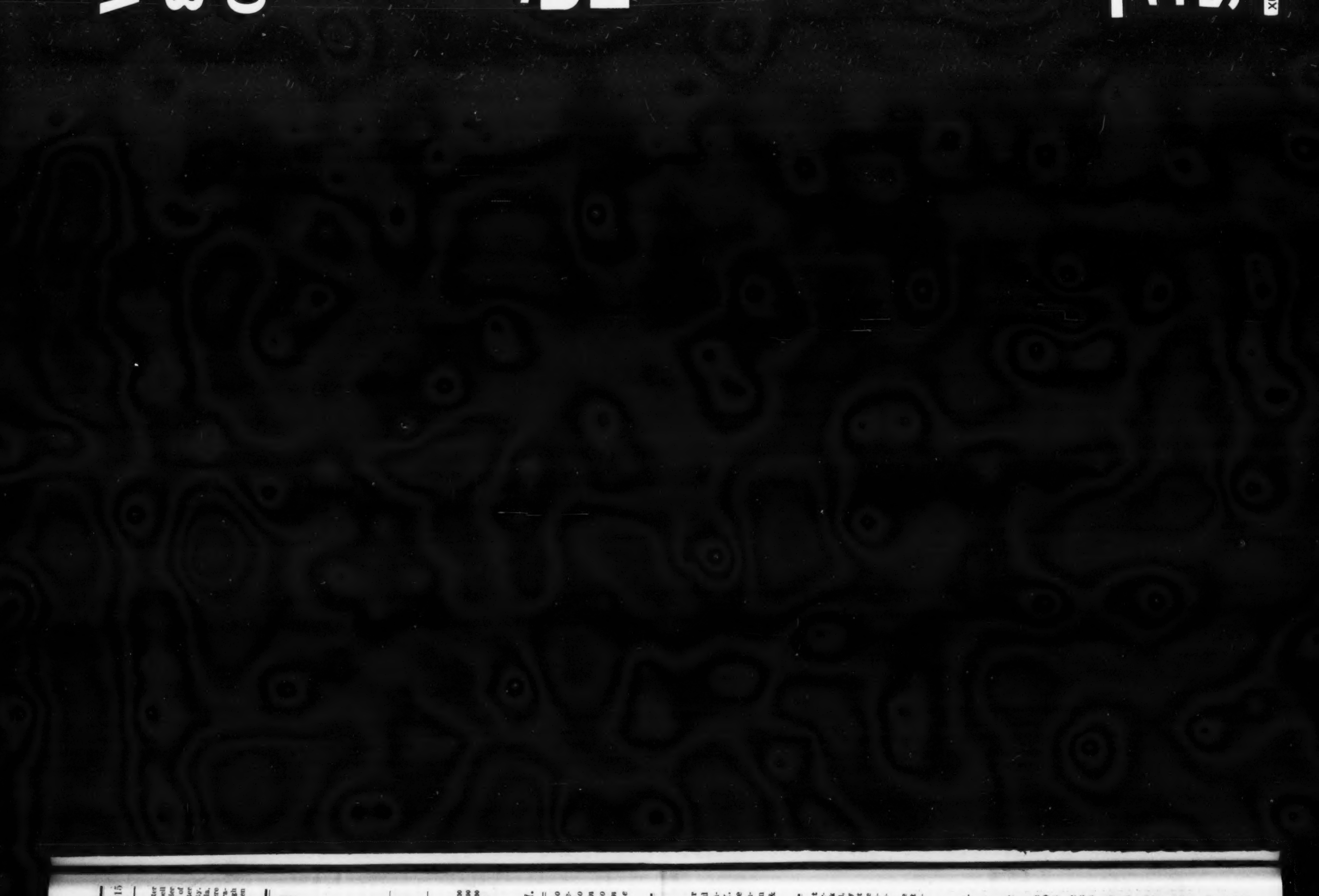
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